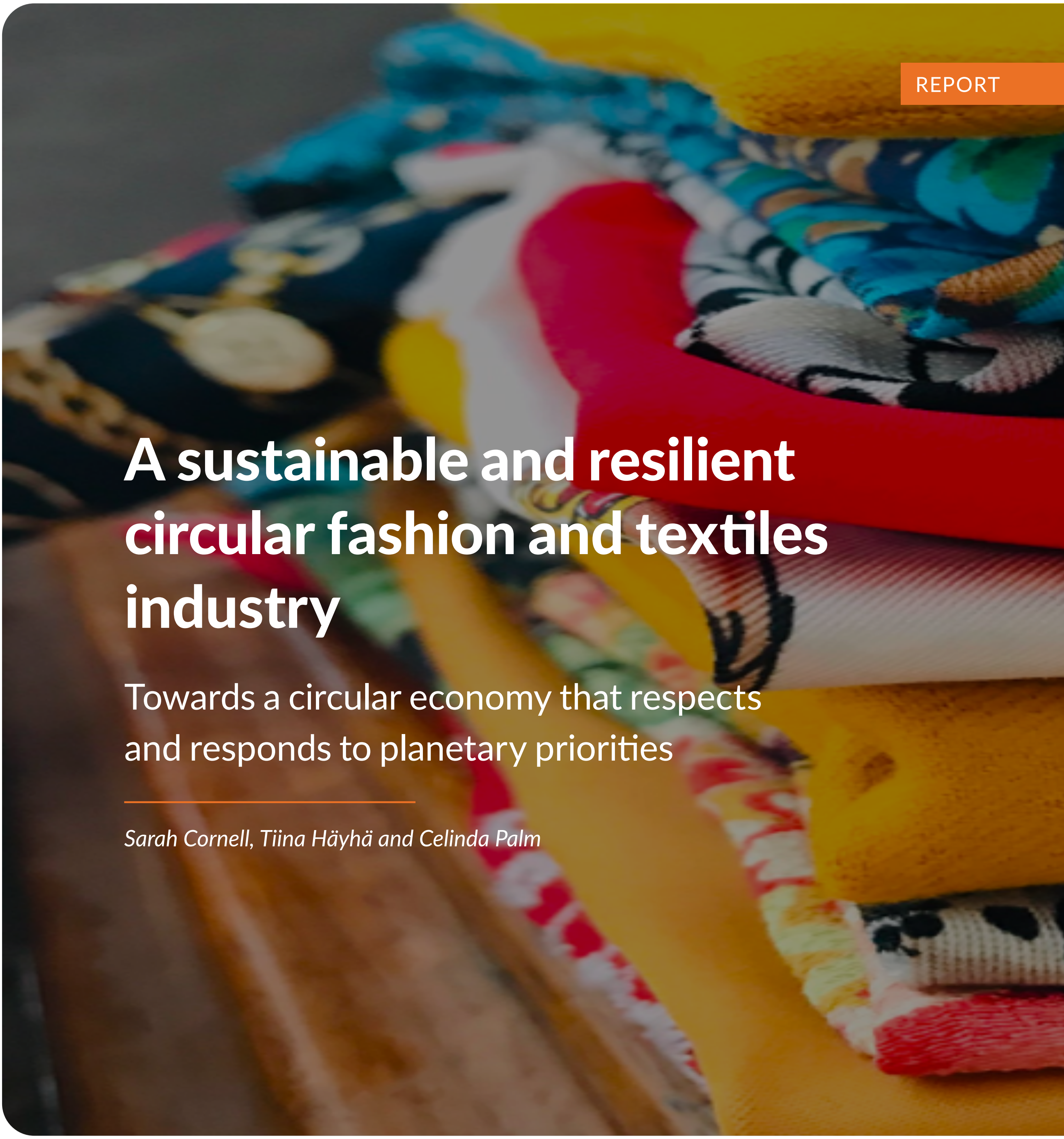


REPORT

A sustainable and resilient circular fashion and textiles industry

Towards a circular economy that respects and responds to planetary priorities

Sarah Cornell, Tiina Häyhä and Celinda Palm

Stockholm Resilience Centre
Sustainability Science for Biosphere Stewardship
Stockholm University

A PARTNER WITH
Beijer Institute of Ecological Economics
KUNGL. VETENSKAPS AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

Lead Authors (in alphabetical order):
Sarah Cornell
Tiina Häyhä
Celinda Palm

With contributions from:
Jacob Hileman
Ivan Kallstenius
Patricia Villarrubia-Goméz
Stockholm Resilience Centre

And the Ellen MacArthur Foundation

The Sustainable Textiles project was a science-business collaboration. The research was led by the Stockholm Resilience Centre at Stockholm University, informed by the Ellen MacArthur Foundation's work, and funded by H&M Group. This report can be downloaded via www.stockholmresilience.su.se/sustainable-textiles.

Cover photo and graphics: Celinda Palm

Suggested citation: 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.

DOI: 10.5281/zenodo.4561847

Version: 2021-03-31

SUMMARY

Tackling planetary priorities by applying circular economy principles can help the fashion and textiles industry to adapt resiliently to today's rapidly changing social and environmental realities

The fashion and textiles industry urgently needs to take a planetary perspective

Global apparel production and consumption are enjoying a rising trajectory, but too often contribute to negative social and environmental impacts. As planetary pressures mount, the industry is exposed to rising systemic risks. Tackling them requires worldwide action.

The fashion and textiles industry plays a vital role in helping societies to shift from an extractive, wasteful and risk-multiplying value chain to a circular business ecosystem that can adapt resiliently to today's realities.

Tackling planetary pressures with circular economy principles is key to promoting sustainability transformation

Combining the principles of a restorative and regenerative circular economy with clear science-based priorities derived from the planetary boundaries can create a firm foundation for a sustainable fashion and textiles system.

- Circular economy aims to be regenerative – planetary boundaries explain what needs to be regenerated
- Circular economy calls for 'closing the loop' of linear value chains – planetary boundaries indicate what changes are needed and how efforts add up
- Circular economy means rethinking of waste as resources – planetary boundaries track Earth's capacity to provide natural resources and absorb waste and pollution.

Circular economy is a strategic response to planetary pressures

The fashion and textiles industry already takes action on several sustainability challenges – but efforts are often piecemeal. Strategic science-based coordination of action for circularity can cover all planetary priorities and help prevent efforts in one area undermining progress on the others. Climate change and biodiversity together define the Earth system conditions that need maintaining. Land and water use, nutrient and pollutant flows are the main drivers of Earth system change, and their interactions introduce unprecedented threats.

Six planetary priorities: already acute pressures where today's trends intensify global risks

Cut carbon emissions to mitigate climate change and ocean acidification
Climate change alters conditions for all life on Earth. Current greenhouse gas levels are unprecedented, and as they rise, climate impacts and risks increase. Cutting carbon emissions is the only way to stabilize climate.

Halt and even reverse the loss of biodiversity, on land and in marine and aquatic environments
Biological diversity is being lost, reducing nature's resilience. Maintaining planetary health means protecting and restoring nature: life below water and life on land, both above and below ground.

Minimize land use change, especially where forests are converted to cropland
Land use affects climate and biodiversity, but land demand for fuels, fibres and food is rising. Tackling deforestation is a powerful response to current planetary pressures, but effective efforts should also tackle land degradation and poor land management.

Rapidly improve nutrient use efficiency in natural fibre production, to rebalance global N&P cycles
Nitrogen and phosphorus flows alter the nutrient balance of soils and aquatic systems. N&P fertilisers are vital for crop production, but their harms are globally widespread. Efficient nutrient use is needed.

Minimize the environmental release of harmful chemical substances
Chemical pollution of land, air and water is a major threat to living beings. Long-lived and bioaccumulating substances are of particular global concern. Efforts are needed to prevent their release.

Use freshwater wisely, without depleting or polluting freshwater resources
Water is vital for life, and is under increasing pressure from pollution, overuse and climate change. Water conservation matters, even in areas where water is plentiful. Effective efforts focus on freshwater habitats and their surrounding landscapes.

Sustainable business action targets can contribute to resilient system-change goals

By setting action targets on the planetary priorities now, individual businesses can ensure their circular economy efforts reduce pressures by 2030, and also contribute to the system-wide change across the industry that is needed to meet global goals for the longer term.

Decrease CO_2 emissions by 8% or more per year from 2020, aiming for carbon neutrality by 2050
This ambitious decarbonization target is vital for reaching net-zero emissions. Science-Based Targets specify how a brand's activities contribute to rapid emissions reductions. Coalitions like EP100 and RE100 enable best-practice sharing and industry-wide learning for transformational action in energy systems.

Ensure no net loss of land and marine habitats, aiming for 30% of the world under conservation protection.
Brands need to ramp up ecosystem restoration and conservation efforts fast, halting and reversing the long-term decline of biodiversity losses, while safeguarding human rights. New Science-Based Targets for nature enable brands to assess their own impact on nature and also to contribute together to achieving global biodiversity goals.

Halt deforestation and triple the contribution of climate-smart agriculture to material production, aiming to restore 20% of the world's land area to a well-functioning, climate-stabilizing, ecologically resilient state.
Efficient and resilient agriculture systems, zero deforestation and more reforestation are all needed if global land-use systems are to support the world's needs for bioresources, food and water *and* meet net-zero climate and net-positive biodiversity goals. The Bonn Challenge mobilizes global efforts for landscape restoration.

Reduce freshwater abstraction and consumptive use by 30%, aiming to maintain total freshwater withdrawals below 40% of renewable supplies in all watersheds.
This target reduces direct water security risks to brands and recognises the shared nature of water. Given the vital role of water for all life, stronger methodologies are currently being developed for contextual sustainability metrics that help protect the environmental water flows that sustain resilient landscapes. Brands should be responsive to these developments, and also monitor the 'water footprints' of their products.

Prevent all release of chemicals of high concern. Reduce use of pesticides by 50%. Reduce waste generation through prevention, recycling and reuse, aiming for fully circular and restorative production systems.
Countries have failed to meet SDG Target 12.4 on environmentally sound management of chemicals and wastes. Ensuring that circular economy contributes to global sustainability entails urgently preventing the release of pollution and waste into the environment, bringing transparency all along the value chain, and using best practices for hazardous chemicals (e.g., REACH).

Prevent nitrogen and phosphorus releases by ensuring full compliance with national air and water quality criteria along the supply chain, aiming to improve long-term full-chain nutrient use efficiency by 50%.
Global problems with nutrient element flows (N&P) are worsening faster than scientific assessment can keep up, and SDG Targets for good air and water quality by 2020 have not been met. Brands can take action now by ensuring that local air and water quality targets are met along the supply chain. Future science-based targets will cover N&P.

Contents

Towards a sustainable circular economy **7**

Planetary priorities for the fashion and textiles industry **8**

Why does business need to take a planetary perspective? **8**

What is the state of the planet now? **11**

What are the planetary priorities for business action? **13**

Industry-wide change is needed to tackle pressures on the planet **16**

The fashion and textiles industry is a fast-growing complex system **17**

Problem dynamics lead to rising planetary pressures **18**

Challenging prospects lie ahead **19**

A circular economy can help reduce planetary pressures **24**

Circular economy and planetary boundaries are mutually supportive frameworks **24**

Closing a loop or (re)connecting global ecosystems? **27**

What does this mean for the fashion and textiles industry? **30**

A planet-aware framework for business action towards circular economy **30**

Taking positive action steps **36**

APPENDICES **39**

A. Our social-ecological systems approach: central concepts and methods **39**

B. How are the Planetary Boundaries measured – and how do these scientific measures relate to business? **41**

Figures

1. *The planetary boundaries framework shows current Earth system changes away from Holocene-like conditions…* 7
2. *The business ecosystem is a complex web of organisations whose interactions affect Earth's biosphere at all scales…* 9
3. *The fashion and textiles industry already takes action on several sustainability challenges* 13
4. *The fashion and textiles industry in numbers…* 17
5. *The shift to circularity involves tackling problematic self-reinforcing dynamics* 18
6. *Today's corporate sustainability efforts are cross-linked with the planetary priorities* 19
7. *Synthetic and natural fibres have different patterns of impacts on planetary pressures* 20
8. *Circular economy can reduce planetary pressures by changing resource consumption and use* 24
9. *Business plays a central role in interactions between Earth's natural resources and worldwide value networks* 27
10. *Responding to planetary pressures requires an extended scope of action* 28
11. *Planet-aware business action for a sustainable and resilient circular economy* 30
12. *Business action targets and system-wide goals* 39
13. *The adaptive cycle represents a system's processes of self-organisation and evolution* 40
14. *Elinor Ostrom's general framework for analysing sustainability of social-ecological systems* 41

Tables

1. *The planetary boundary processes are urgent global and transboundary policy issues.* 10
2. *The industry's contributions to planetary pressures* 18
3. *Comparing conventional cotton production and cotton standards on the planetary priorities.* 21
4. *Effects of cotton and synthetic fibre production on the planetary priorities* 23
5. *The Action Hierarchy aligns with circular economy principles..* 36
6. *Measurement, monitoring and reporting tools already exist to track progress* 37

Useful links

- What is a circular economy? https://www.ellenmacarthurfoundation.org/circular-economy/concept
- Future Earth, the international research network for global sustainability https://futureearth.org
- The Global Commons Alliance, 'A big plan for a small planet' http://globalcommonsalliance.org

Towards a Sustainable Circular Economy

The world's current production and consumption systems are pushing far beyond the planetary boundaries. Earth's 'safe operating space' is shrinking. Action is needed

Global apparel consumption is on a rising trajectory, and it is projected to continue to increase rapidly in the coming decade and beyond. This accelerating pace of production and consumption is leading to worsening negative social and environmental impacts. As a result, the fashion and textiles industry is already operating under consumer scrutiny and tightening policy constraints, and can no longer continue with business as usual. Circular economy is an emerging approach to drive economic development decoupled from resource consumption, which benefits society and regenerates the environment.

Achieving a sustainable and circular fashion and textiles system hinges on concerted action across society, involving other industries, policy-makers and (not least) the millions of people who buy and enjoy fashion. The United Nations 2030 Agenda for Sustainable Development emphasises the urgent need for action, and it recognises that planet-scale changes now place pressing constraints on development and drive rising risks to future prosperity. The planetary boundaries framework[1] for global sustainability describes the large-scale, long-term environmental conditions on Earth that have maintained a 'safe operating space' for humanity – but this planetary stability is increasingly under pressure because of the activities of the world's societies.

Throughout this report, we link circular economy principles with the planetary boundaries framework, helping to set business decision making within its globally interconnected social and environmental context. We describe how the planetary boundaries can be translated to baselines of global responsibility for resource use and negative externalities. We outline the planetary priorities for setting science based targets at the necessary level of ambition to steer and track business action that reduces the pressures on Earth's safe operating space.

In short, we show how applying circular economy principles can help societies shift from an extractive, wasteful and risk-multiplying value chain to a circular business ecosystem for a fashion and textiles industry that can adapt resiliently to today's environmental realities.

Planetary boundaries and circular economy – key concepts for a sustainable future

The ***planetary boundaries*** framework (**Figure 1**) shows how human activities have shifted Earth's natural processes away from the 10 000-year stable baseline of the Holocene epoch[2]. This is a relatively short window in geological time, but it is an important timeframe because Earth's climate and living nature have been relatively stable, allowing for today's societies to establish and thrive. The further the world goes beyond this 'safe operating space', the higher the risks of disruptive environmental change. Some processes in the framework are already acutely under pressure, and current production and consumption trends are making the problems worse. A focus on these processes defines science based priorities for global responsibility on resource use and environmental harms.

Circular economy provides actionable principles for economic development that benefits society and works in harmony with the living environment. A circular economy regenerates natural systems, keeps products and materials in use, and designs out waste and pollution. Combining circular economy principles with the priorities flagged in the planetary boundaries framework can create a firm foundation for a restorative and regenerative fashion and textiles system.

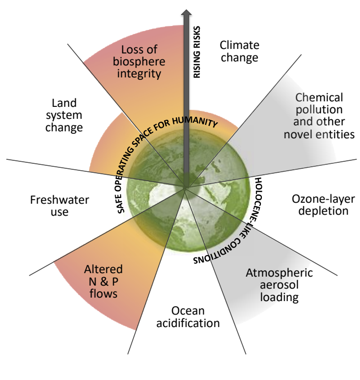


Figure 1 – The planetary boundaries framework shows current Earth system changes away from Holocene-like conditions

[1] J Rockström and colleagues 2009. A safe operating space for humanity. Nature 461: 472–475. https://doi.org/10.1038/461472a

[2] W Steffen and colleagues 2015. Planetary boundaries: guiding human development on a changing planet. Science 347: 1259855

Planetary priorities for the fashion and textiles industry

Today's 'take-make-use-waste' value chains are not resilient and are risk multipliers on all the planetary priorities. System change is needed

Why does business need to take a planetary perspective?

Much of today's global economy is a bio-based economy, dependent on the continued production and trade of Earth's living resources for food, fodder, feedstocks, fibre and fuel. Yet the scientific community has warned that the global scale and accelerating rates of human-driven changes are fundamentally altering the ways that our living planet functions. Future resource flows will be affected by environmental changes and by increasing climate variability. Productive areas will shift, changing the political context of trade. In this context, societies worldwide are mobilizing for 'cleaner and greener' goods, environmental change has become an international political priority, and the textile fashion industry is in the spotlight.

The situation is growing urgent. In 2015, the world's nations agreed on 17 Sustainable Development Goals. These global goals press for concerted action on climate change, biodiversity loss and environmental protection in line with international agreements, as well tackling many other unwanted and unsustainable impacts associated with today's production and consumption systems. Yet by 2020, progress remains uneven and the world is not on track to meet the SDGs by 2030[3].

Business plays a major role in the global response to these planetary changes. The timescales that matter most to the business world are typically very short, when set against the long-term dynamics of global environmental changes. But now that the pressures on planetary processes are high and risks are rising, the quarterly and annual planning cycles of business are vital parts of society's ability to adapt responsively to changes and avoid the worst risks. It is time for businesses to take Earth's large-scale and long-term system conditions into account in their decision-making for sustainability and resilience.

The planet's 'safe operating space' is under pressure

The planetary boundaries framework highlights the rising risks of systemic environmental change. It consists of a global status-check on nine environmental change processes where human activities are driving the Earth outside of the comparatively stable and predictable biophysical conditions seen over the past 10 000 years. These processes interact, altering the functioning of the whole Earth system with implications for the worldwide resilience of today's societies and globalised economies. When the global status-check is combined with information about current trends in human-caused pressures, the planetary boundaries framework can be seen as a dashboard of red-alert messages about changes to the long-term state of the global environment.

The quantifications of the framework's nine processes draw upon worldwide scientific efforts, including the periodic assessments of global change made by international science-policy forums such as the IPCC and IPBES.[4] Much of the scientific evidence base for the framework is maintained by the global research projects of the international science strategy network Future Earth[5]. The framework's processes are also covered by various international policies, like the Paris Agreement for climate change. **Table 1** outlines this science and policy context.

The science-based, policy-relevant framework provides a *systemic* basis for responding to the changing dynamics of the whole Earth, rather than treating environmental changes as separate reasons for concern. The framework gives a foundation for setting precautionary constraints to minimise the societal risks of linked global environmental changes. Some important ideas need to be kept in mind when the planetary boundaries framework is put into practice:

[3] United Nations 2020. The Sustainable Development Goals Report 2020. https://unstats.un.org/sdgs/report/2020/The-Sustainable-Development-Goals-Report-2020.pdf

[4] IPCC is the Intergovernmental Panel on Climate Change, www.ipcc.ch. IPBES is the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, www.ipbes.net

[5] futureearth.org

The planetary boundaries involve tightly interconnected Earth system processes, even though the boundaries are quantified separately. As human-caused pressure on one boundary continues to intensify, the 'operating space' demarcated by the others will shrink – but in poorly predictable ways. Researchers are developing nexus methods[6] that help to analyse and deal with multiple issues at once, such as climate, land use, ecosystem health and water resources.

The boundaries highlight unsustainable trends where worldwide action is urgently needed. Even where there may still be uncertainty about a boundary's quantification in terms of its Holocene baseline, the problematic trends need to be halted and where possible reversed in order to maintain the stability and resilience of Earth's living systems. There is already enough scientific and socioeconomic evidence of the need to act urgently on all the global change issues flagged in the planetary boundaries framework.

The planetary boundary processes are global and transboundary policy issues. Action to reduce pressures on these processes supports the achievement of the SDGs, as well as the implementation of many other multilateral environmental agreements regionally and globally for a healthy planet.

The boundaries are a large-scale complement to local impact indicators. The framework is not intended to substitute for local sustainability efforts. Continued intense pressure on the boundaries will have very different local effects in different parts of the world, and there are many situations where local action is needed even if a planetary boundary is not breached (as in the case of freshwater use).

The global business ecosystem is embedded in the planetary ecosystem

Businesses often use the term 'business ecosystem' to describe the complex interactions that form between organisations as they cooperate and compete to deliver on their value propositions. In today's globalised economy, many of these connections now span the world. The global business ecosystem for sustainable fashion and textiles (**FFigure 2**) comprises a complex worldwide network of clothing brands, retailers, manufacturers, and trade associations – and also advocacy campaigns, multi-stakeholder platforms, and various other issue-based organisations.[7]

The challenge businesses now face is to recognize that they also operate as 'organisms' within the planetary ecosystem, and are subject to influence and constraints from the natural world. Business decision-making interacts with biophysical, social, political and technological factors in ways that have complex consequences for society and the environment. Because of this it can be helpful to think in terms of the whole world as a tightly linked *social-ecological system.*[8] (Read more about how we use this systemic approach in **Appendix A.**)

However, businesses mainly think of the business ecosystem in relation to the direct economic partnerships they maintain within their own value chains. Each business occupies its own niche, naturally focusing most on their direct connections with suppliers and customers, and not always recognizing the vital contributions of the living world.

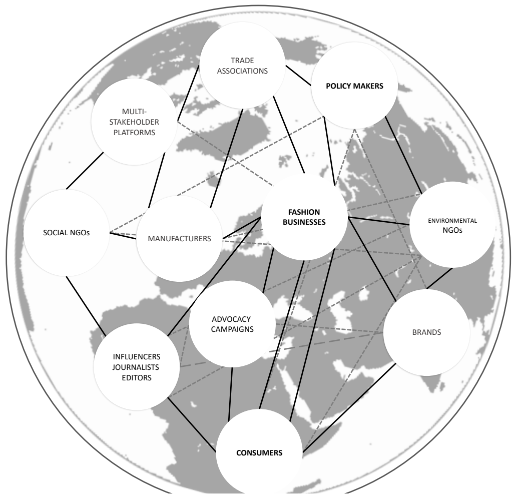


Figure 2 – The fashion and textiles industry's business ecosystem is a complex web ganisations[13] whose interactions affect Earth's biosphere at all scales

This means that even global businesses usually see only part of their place in the planetary system. Businesses often map their value chain geographically in terms of the locations of their production sites, main offices and key customer bases – but businesses also need to recognise that the planetary map of the true social and ecological impacts of their material activity may be very different from these places. Business actions ripple through the whole system. These interactions scale up, from business actions to worldwide impacts on societies and the natural environment. Interactions also scale down, as changes in social and environmental contexts and planetary conditions have impacts on individual businesses.

[6] DL Bijl and colleagues 2018. Unpacking the nexus: Different scales for water, food and energy. *Global Environmental Change* 48: 22-31

[7] J Hileman and colleagues 2020. Keystone actors do not act alone. *PLOS One* 15(10): e0241453

[8] F Berkes and colleagues 2002. *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press

Table 1 – The planetary boundary processes are urgent global and transboundary policy issues. Scientific consensus about their importance is strong, and international science-policy forums support measurement and monitoring of global changes. Business action is needed to tackle these issues. It can also help make companies more policy-compliant and prepared for future changes.

Global scientific assessments	Multilateral policy agreements and supporting science-policy forums	Links to the 2030 Agenda
Climate change and Ocean Acidification		
'Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia' – IPCC 2013/2014 Synthesis Report (the most recent global assessment). See previous IPCC Assessment Reports and Special Reports: www.ipcc.ch/assessment-report UN Human Development Reports 2007/2008 and 2014 also assess climate and society. ***'Ocean acidification will continue for centuries if CO_2 emissions continue, it will strongly affect marine ecosystems, and the impact will be exacerbated by rising temperature extremes'*** – IPCC 2013/2014 Synthesis Report. IPCC Working Group II Assessment Reports assess the physicochemical state of the world's oceans. There is no comprehensive global assessment yet of social and ecological impacts of ocean acidification, but for a useful overview see: www.epoca-project.eu	The main international agreement is the UN Framework Convention on Climate Change and its 2015 Paris Agreement. The Vienna Convention and its Montreal Protocol control emissions of ozone-depleting substances which are also powerful greenhouse gases. The UN Economic Commission for Europe's Convention on Long-range Transboundary Air Pollution sets emission targets for short-lived climate pollutants such as soot, with signatories across most of the northern hemisphere. The main science-policy forums for climate and ocean acidification are the Intergovernmental Panel on Climate Change (www.ipcc.ch) and the UNFCCC's Subsidiary Body for Scientific and Technological Advice (https://unfccc.int/process/bodies/subsidiary-bodies/sbsta).	SDGs 13 and 7 are directly linked to climate change and ocean acidification.
Biodiversity loss and ecosystem change		
'Nature across most of the globe has now been significantly altered by multiple human drivers, with the great majority of indicators of ecosystems and biodiversity showing rapid decline' – Summary for Policy Makers, IPBES Global Assessment 2019. Other global assessments include the CBD Global Biodiversity Outlooks GBO1-5, www.cbd.int/gbo; UN Environment's Global Environment Outlooks GEO1-6; the Millennium Ecosystem Assessment 2005; The Economics of Ecosystems and Biodiversity (TEEB 2010); and many UN Food and Agriculture Organisation Assessments, notably the *State of…* reports on food and agriculture, fisheries and aquacultures, forest resources, etc.	The main agreements are the UN Convention on Biological Diversity, the Convention on International Trade in Endangered Species, and the Ramsar, Bonn and Bern Conventions that deal with different aspects of nature conservation and sustainable use. For more information see www.cbd.int/ecolex. The main forums are the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (https://ipbes.net), and the CBD's Subsidiary Body on Scientific, Technical and Technological Advice (www.cbd.int/sbstta).	SDGs 14 and 15 are directly linked to biodiversity loss and ecosystem change.
Land use		
'Changes in land conditions affect global and regional climate. [...] Sustainable land management, including sustainable forest management, can prevent and reduce land degradation, maintain land productivity, and sometimes reverse the adverse impacts of climate change on land degradation' – Summary for Policy Makers, IPCC 2019 Special Report on Climate Change and Land Land use and land use/cover change are routinely included in UN Environment's GEO and the CBD's GBO assessments, the FAO's *State of the World's Forests* reports, etc.	The main agreements dealing with land use are the UN CBD and the Convention to Combat Desertification. Land use is primarily a matter for national sovereignty and jurisdiction, except where transboundary issues apply. The main international science-policy forum for land system change is the Global Land Program (https://glp.earth). Land use is also the focus of international sector organisations such as CGIAR (www.cgiar.org, supporting agricultural research and innovation).	SDG 15 is focused on land systems, and land also plays a vital role in SDGs 2, 12 and 15.
Freshwater use		
'Water-related risks arise from human interference in the aquatic environment. [...] The threats are multiple, and they interact - undermining catchment and coastal systems' capacities to deliver ecosystem services.' – GWP/OECD Task Force on Water Security and Sustainable Growth, 2015. UN World Water Development Reports have been produced since 2003. UN-Water produces Global Analysis and Assessment of Sanitation and Drinking Water (GLAAS), with periodic reports 2008-2016 and thematic assessments 2017-2019.	The main international policy processes for water are the UNFCCC's National Adaptation Plan system, and the 2030 Agenda's SDG 6. Water use primarily comes under national sovereignty and jurisdiction, unless transboundary issues apply. Forums include the Global Water Partnership (www.gwp.org), the World Water Council (www.worldwatercouncil.org), and the Global Water Forum (https://globalwaterforum.org). Water is a priority theme in the UN Food and Agriculture Organisation (www.fao.org) and World Health Organisation (www.who.int).	SDG 6 is focused on water systems, and water also plays a vital role in SDGs 3, 11, 12 and 15.

Global scientific assessments	Multilateral policy agreements and supporting science-policy forums	Links to the 2030 Agenda
Chemical pollution (novel entities)		
'Hazardous chemicals and other pollutants continue to be released in large quantities. [...] highlighting the need to avoid future legacies through sustainable materials management and circular business models' – UNEP Global Chemicals Outlook II, 2019 Most studies of chemical pollution are regional or topical. In 2013, UNEP published the first Global Chemicals Outlook and a report on the costs of inaction on the sound management of chemicals (www.unep.org/hazardoussubstances). The intergovernmental Joint Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP) makes global assessments on marine pollution, including plastic waste.	International agreements include the Stockholm Convention on Persistent Organic Pollutants, the UNECE's CLRTAP, and other conventions on waste and dumping. Regional policies are also influential, e.g. Europe's REACH regulation. Forums include the WHO Intergovernmental Forum on Chemical Safety (www.who.int/ifcs) and international industry-linked societies such as the Society of Environmental Toxicology and Chemistry (www.setac.org) and the Society of Chemical Industry (www.soci.org).	SDGs 3, 9 and 12 are directly linked to chemical pollution.
Biogeochemical change – nitrogen and phosphorus (N&P) flows		
'Major threats from nutrient enrichment and changing nutrient ratios are the development of dead zones and toxic algae blooms in inland and coastal waters. Trends are projected to continue in the wrong direction' – UNEP GEO 6, 2019 Global N &P assessments are infrequent. Key reports are the Global Program on Nutrient Management's 'Our Nutrient World' 2013 and the 1990 GESAMP Report on the Marine Environment.	No global conventions specifically target N&P but nutrient flows feature in many agreements, such as UNFCCC and CBD (e.g., Aichi Target 8). UNECE's CLRTAP and Water Convention and HELCOM (Baltic nations, EU) and OSPAR (North Sea, NE Atlantic) deal with transboundary issues. Forums dealing with N&P flows include the International Nitrogen Initiative (initrogen.org), the Global Phosphorus Research Initiative (phosphorusfutures.net), Global Partnership on Nutrient Management (www.nutrientchallenge.org), and expert groups linked to FAO, WHO, IPCC and the World Meteorological Organisation.	SDGs 3, 6, 14 and 15 are most directly linked to nutrient flows.
Altered atmospheric composition – depletion of the stratospheric ozone layer, atmospheric aerosol loading		
'There has been an unexpected increase in global total emissions of CFC-11. Continued success of the Montreal Protocol in protecting stratospheric ozone depends on continued compliance with the Protocol.' – WMO/UNEP Scientific Assessment of Ozone Depletion 2018. ***'Particulates tend to reduce rainfall but increase the likelihood of intense storms.'*** – Millennium Ecosystem Assessment 2005 Global assessments linking atmospheric chemistry, climate and ecosystems are infrequent. Changes in aerosol conditions are reported in IPCC Working Group I Assessment Reports (Physical Basis).	The main agreement to tackle ozone depletion is the Vienna Convention and its Montreal Protocol. Agreements that cover aerosols (particulate matter) are UNECE's CLRTAP and the UNFCCC, because aerosols are important in climate. The main science-policy forums are UN Environment's Ozone Secretariat (ozone.unep.org), the Global Emissions Initiative GEIA (geiacenter.org), the UNECE's monitoring and evaluation programme EMEP (www.emep.int), and for the marine context, the intergovernmental Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (www.gesamp.org).	SDGs 7, 9, 11 and 12 are most directly linked to air pollution and related issues.

What is the state of the planet now?

Planet Earth is entering the Anthropocene

Earth is a living planet, and its environment has always experienced change. In order to understand the implications of human-driven global environmental changes, today's changes need to be set into the context of the pace and scale of processes in the past.

Earth system science is the study of how the biological, geochemical and physical behaviour of the planet changes over time in response to different driving forces. The current human-driven problems of climate change and biodiversity loss are widely known. **Table 1** indicates some of the global scientific assessments that give ever-clearer insights about other problematic global environmental changes.

This evidence shows that the world's societies are exiting the conditions of climatic and ecological stability and – importantly for business – the predictability of the Holocene. Human-caused pressures are rising on seven of the nine planetary boundaries, most of which are now outside the range of conditions seen at any time during the past 10 000 years. Only stratospheric ozone depletion has shown an improving trend, while atmospheric aerosols show a globally mixed pattern with improvements in places where air quality policies have been implemented.

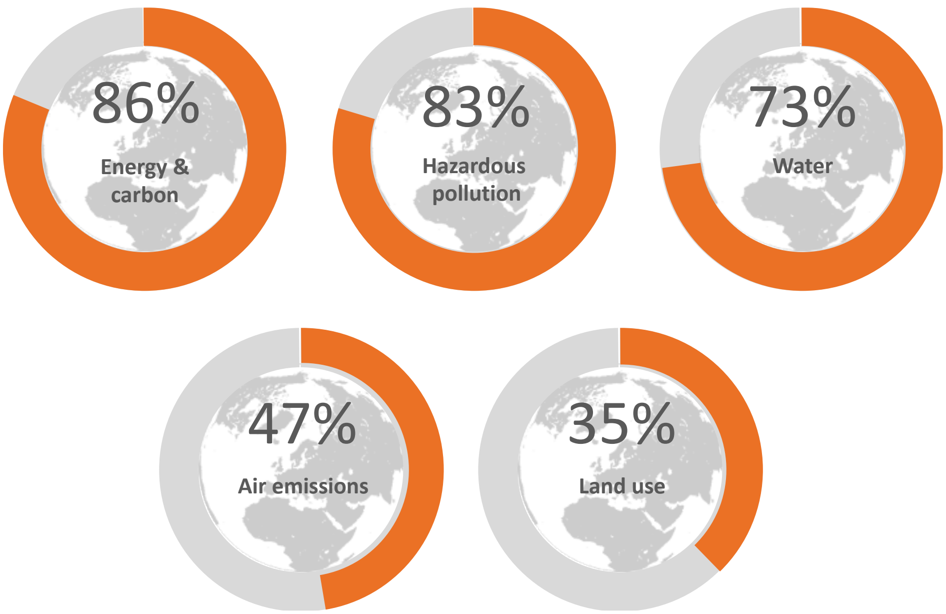
Global business is starting to recognize global change risks

Environmental changes are increasingly recognised as globally systemic risks – but the big challenge for business is how best to respond to such large and complex pressures.

Businesses in the fashion and textiles industry are already making efforts to tackle environmental problems **(Figure 3)**. Many sustainability efforts are focused on making progressive environmental improvements of products and processes. Tracking incremental improvements in resource use and waste and pollution reduction plays a vital role in improving ***eco-efficiency***: more value can be generated while environmental impacts are reduced. But when the changes are made are marginal, selective and only measured and reported on a relative scale (for example, '*product X generates 10% lower carbon emissions than product Y*'), it is impossible to tell whether they 'add up' in ways that actually reduce the overall pressures on the environment and the associated risks in the value chain.

The multi-indicator planetary boundaries framework provides a scientific basis for a global baseline against which to benchmark the overall consequences of actions. The framework can help business to demonstrate shifts towards ***eco-effectiveness***: the transformation of the material flows of production and consumption to sustain regenerative and resilient ecosystems that support future value creation. The framework adds new larger scale and longer term systemic dimensions to existing corporate sustainability efforts. It provides a way to set priorities for positively mitigating the risks of large-scale environmental threats and resource scarcities. It highlights the need to keep all these planetary priorities in focus at the same time, so that actions to improve in one area do not undermine possibilities to improve in the other areas.

Figure 3 – The fashion and textiles industry already takes action on several sustainability challenges. Plots show the fraction of the top 200 global fashion brands in the Fashion United 2016 list that report addressing each environmental challenge area in their sustainability reports. Analysis: J Hileman and I Kallstenius



What are the planetary priorities for business action?

Planetary priorities are the environmental processes in the planetary boundaries framework where present-day trends in society's activities are intensifying already severe global pressures. These processes give a clear set of **six planetary priorities** for business action in order to maintain the stability and resilience of the Earth system.

Tackle carbon emissions

Why is action needed?[9] Already, observed climate changes include increased weather hazards such as droughts, storms and heatwaves. Longer term threats arise from sea level rise, thawing permafrost and melting ice. Climate change is tightly linked to ocean acidification, a change that affects all marine life. Social and economic impacts are already high, becoming less predictable as the world moves further into a no-analogue state.

Why focus on carbon? Rising emissions of carbon dioxide (CO_2) cause both climate change and ocean acidification, so these two planetary boundaries become one planetary priority for action. The planetary boundaries assessment places current CO_2 levels well outside the safe operating space for humanity. Current CO_2 levels exceed 410 parts per million (ppm), against a planetary boundary of 350 ppm and Holocene levels of about 280 ppm. At the same time, CO_2 is dissolving in the oceans. The planetary boundaries assessment tracks ocean acidification using the seawater saturation state of aragonite, a carbonate mineral formed by many marine organisms. The current saturation state is approximately 84% of the preindustrial value, close to the 80% level of the planetary boundary.

What is the action challenge? Progress on necessary energy shifts and climate change mitigation is much too slow. Global carbon emissions are rising as industrial production expands and as natural land is changed to other land uses (which often releases carbon to the atmosphere). In parts of the world national emissions have stabilised or even decreased, but as more information is gathered about national patterns of consumption as well as production, it is clear that these reductions have not really decoupled the economy from its problematic climate impacts, but have often come at the cost of externalising emissions elsewhere in the world.

Halt the loss of biodiversity

Why is action needed? Although nature does not exist to serve humanity, it gives 'ecosystem services' on which all people depend. The diversity of life makes production systems more resilient to shocks and stresses, and buffers effects of climate change. But ecosystems, wild populations and local varieties of domesticated plants and animals are declining, deteriorating or disappearing entirely as a result of human activities. The biophysical world is less resilient and more vulnerable. Recent global assessments show how damage to the web of life is now a direct threat to human wellbeing in all regions of the world[10]. Ecological damage undermines the chances of meeting social goals such as the Paris climate agreement and the 2030 Agenda's SDGs.

Why focus on biodiversity loss? The planetary boundaries assessment places current losses of biological diversity far beyond the Holocene baseline. The closest comparisons for today's scale of species extinctions and habitat changes are major extinction events in geological history. Global maps of the Biosphere Integrity Index[11] show large areas of the world where the planetary boundary has been breached. Threats to nature are rising to the point that conservation of wildlife alone is far from being an adequate response – ecosystem restoration and regeneration are needed.

What is the action challenge? Threats to biodiversity interact with climate and pollution pressures, making complex risk multipliers. The CBD's 2020 Aichi Targets were not met, so the outlook for biodiversity is a cause for worldwide concern. Stepping up ambition involves reconnecting to the whole biosphere, reversing harms to life in the oceans, on land and below ground. This requires new ways to sustain the material contributions of nature to people from agricultural production, the harvesting of land and marine natural resources and the capacity of ecosystems to decompose and detoxify wastes.

[9] IPCC 2018. *Global Warming of 1.5°C.* IPCC Special Report, eds V Masson-Delmotte and colleagues.

[10] IPBES 2019. *Global Assessment Report on Biodiversity and Ecosystem Services.* Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany.

[11] T Newbold and colleagues 2016. Has land use pushed terrestrial biodiversity beyond the planetary boundary? *Science* 353: 288-291

Minimize land take

Why is action needed? The world's land resources need to be better managed so they can meet the multiple demands expected of them.[12] When forests and other natural lands are converted for infrastructure and resource production, environmental degradation is inevitable, often with undesirable social outcomes. Supply chain related land use changes drive biodiversity loss, water cycle disruption and climate change (loss of forests and soils destroy long-term carbon stocks; conventional biomass production has short-term cycles of carbon sinks and sources). Many land uses also expose land to contaminants.

Why focus on land take? The planetary boundaries assessments place land system changes outside the safe operating space for forested lands (just 62% of original forest cover remains), and on the margin for croplands (more than 12% of ice-free land is used). But qualitative changes also matter for both these land types: land degradation has reduced productivity in over 20% of the world's area. Ecosystem functions are lost, nearly irreversibly, when previously undeveloped land is brought into use.[13]

What is the action challenge? In addition to land-use climate commitments made under the Paris Agreement, several SDGs have targets relating to land use, reflecting its importance for livelihoods, health, gender equality, biodiversity, food systems and resource security. Cascading risks have impacts across these connected systems and sectors. Action is needed on many fronts: first, avoiding converting green areas, and also improving management of 'working lands' like farmlands and pastures, restoring forests and renaturing brownfield sites.

Use water wisely

Why is action needed? Water is vital for all socioeconomic development and for resilient ecosystems. Climate change will increase water scarcity, water-related extreme events and water demand, and the level of future risks will depend on patterns of production, consumption, land management, and technology developments.[12] Agriculture and energy production are already major users of global freshwater, so shifts to bio-based resources will also compound water stresses.

Why focus on wise use? The freshwater use planetary boundary indicates quantitative global change to the water cycle, but context matters greatly in applications at other scales, where water risks are already a threat to the industry. Wise use of water recognises the social and ecological contexts, going beyond freshwater conservation to consider water quality and waste flows, include integrated water management, and respect environmental water flow requirements.

What is the action challenge? Most companies focus on water risks in their manufacturing and operations. Action requires much better oversight of water use and pollution at other stages in the value chain.[14] Major information challenges still constrain action: few tools are available for linking supply chain assessment with spatial assessments and projections of water resources and ecosystem health, and policies for sector allocation.

[12] IPCC 2020. *Summary for Policymakers: IPCC Special Report on Climate Change and Land,* Geneva, Switzerland

[13] IPBES 2019. *Summary for Policy Makers: Global Assessment*, Bonn, Germany; Science for Environment Policy 2016. *No net land take by 2050?* Future Brief 14. European Commission DG Environment / Science Communication Unit, UWE, Bristol, UK

[14] CDP 2020. *Interwoven risks, untapped opportunities*. CDP Worldwide, London, UK

Improve nutrient use efficiency

Why is action needed? A shift to bioeconomy relies on high and sustained agricultural production, but altering the balance of N&P flows will change land and marine ecosystems far beyond the farms, as organisms respond to shifting supplies of the essential nutrients. N&P flows create a chronic global problem that is tightly coupled to climate change, because nitrogen emissions include greenhouse gases (N_2O) and air particulate matter.

Why focus on 'use efficiency'?[15] The planetary boundaries assessment starts from the premise that managing N&P flows through the Earth system demands tackling them effectively at source. Once N&P have been applied or released in the environment, they cascade through soil, air, water and living organisms. Long-range transport (especially of nitrogen) means severe impacts can arise far from sources, needing transboundary management.

What is the action challenge? Global N&P cycles are a low-visibility ecosystem service, rarely featured in business discussions. Until now, 'impair-then-repair' action has been taken when local air, water and ecosystem problems become acute. The outlook for N&P entangles resource constraints, food and energy security and ecosystem health. This complexity calls for improved nutrient use efficiency at every stage in N&P cycles.

Avoid releasing harmful substances

Why is action needed?[16] Global trade and use of chemicals is growing and pollutants are accumulating in materials stocks and the environment. Many substances with harmful impacts are not soundly managed, so risks and liabilities will become less predictable. Growing evidence shows large-scale systemic effects of pollution as well as local ecosystem and health impacts. So far, shifts to bioeconomy rely on conventional agricultural production, increasing pesticide and agrochemicals use.

Why focus on pollution? In addition to the N&P flows discussed above, the planetary boundaries framework highlights three other changes to Earth's fundamental chemistry: pollution by novel substances, ozone layer thinning, and changes in air particulate matter. All relate to the release of pollutants that affect biosphere integrity and (ultimately) climate, so these three planetary boundaries become one planetary priority for business action. Planetary threats are greatest for bioaccumulating, persistent and toxic chemicals ('substances of very high concern').

What is the action challenge? Precautionary responses are needed, along with absolute reductions in the use of harmful substances. Treating large-scale long-term systemic pollution only as a local problem is far from being an adequate response, but transparency, monitoring and reporting systems are lacking. Chemicals and waste management policies are poorly integrated, making life-cycle management very difficult. Increasingly complex supply chains tend to end up with externalised pollution to less regulated parts of the world.

[15] MA Sutton and colleagues 2013. *Our Nutrient World: Global Overview of Nutrient Management*. Centre for Ecology and Hydrology, Edinburgh / GPNM and International Nitrogen Initiative.

[16] UN Environment 2019. *Global Chemicals Outlook II.* Nairobi, Kenya.

Translating metrics from science to business

The planetary boundaries on their own do not give absolute sustainability metrics for business. One key reason is that the biophysical measures used for quantifying the planetary boundaries (**Appendix B**) are global metrics used to observe, model and analyse Earth system change over timescales from decades to millennia. These specialised technical measures are not directly applicable in the more rapid and responsive contexts of policy and business decision-making.

The 'control variables' of the planetary boundaries need to be translated to metrics and targets that are appropriate for tracking ecological changes and their social drivers on much shorter timeframes and all along the industry's value chain. Each context where the planetary boundaries framework is applied – whether regional, national, sectoral or product-level – requires a different translation method.

Unfortunately, many applications of the planetary boundaries framework are likely to encounter problems of data availability, for two main reasons in addition to the timescale mismatch mentioned above. The first is the fact that data gathering in scientific and corporate worlds address very different aspects of the planetary social-ecological system and focus on different underlying dynamics and connections. Also, different assumptions and simplifications are needed in science and business contexts. For instance, businesses typically track their financial flows with much higher precision than they track the flows of physical and embodied environmental resources (such as embodied energy, water and materials) through their supply-consumption chains. The second reason for data constraints is that global systems themselves are changing rapidly. New system-wide connections, both social and ecological, are becoming more evident the further the planetary boundaries are breached. For example, changes in land use change patterns of rainfall and local climate conditions elsewhere. These linked dynamics are not well-captured in environmental footprint methods.

At the same time, business has metrics and information resources that can enable new, more sensitive ways to track improvements on planetary pressures, and even to track the changes themselves. In this report, we therefore focus on the most urgent planetary pressures, showing their links to the issues that companies already measure and report.

Industry-wide change is needed to tackle pressures on the planet

The fashion and textiles industry is a fast-growing complex system

Over recent decades, the industry's material resource use, production and sales have all increased exponentially – and industry-related social and environmental impacts have extended globally (**Figure 4**), creating complex links and spillovers between the industry, its many stakeholders and the natural world. Seen from a systemic perspective, unless the industry rapidly changes its practices, its activities will continue to contribute to environmental harms and social challenges.

Most sector projections expect the fashion and textiles industry to continue to grow in decades to come.[17] They extrapolate current trends into the future, expecting that a larger, healthier and wealthier global consumer base will continue to want to buy fashion textiles. But as the industry expands globally, it uses more fossil-fuel based feedstocks and also extracts more resources from the living world. Earth's capacity to maintain the provisioning of raw materials and assimilate polluting emissions can become a constraint on industry growth.

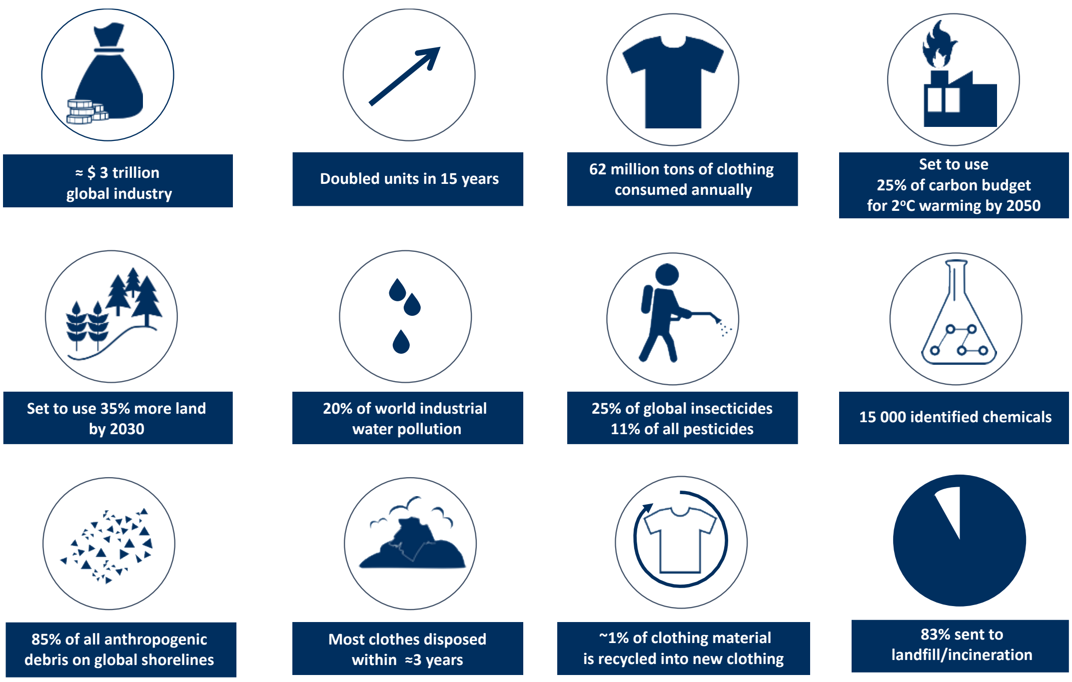


Figure 4 – The fashion and textiles industry in numbers[18]

[17] Mckinsey&Company 2019, *The State of Fashion 2019*; Global Fashion Agenda (GFA) & Boston Consulting Group 2017, *Pulse of the Fashion Industry*; Ellen MacArthur Foundation 2017, *A New Textiles Economy*

[18] Information sources, top left to right bottom:
N Anguelov 2015. *The Dirty Side of the Garment Industry*. CRC Press.
Ellen MacArthur Foundation 2017. *A New Textiles Economy*, www.ellenmacarthurfoundation.org/assets/downloads/publications
D Watson and colleagues 2017. *Call to Action for a Circular Fashion System*. Copenhagen K: Global Fashion Agenda;
WRAP 2017. *Valuing Our Clothes: The Cost of UK Fashion*. https://wrap.org.uk/sustainable-textiles/valuing-our-clothes;
GFA 2019. *Pulse 2019*. www.globalfashionagenda.com/pulse-2019-update
R Rathinamoorthy 2019. Circular Fashion. In: *Circular Economy in Textiles and Apparel*, 13–48. Elsevier
K Kooistra and colleagues 2006. *The Sustainability of Cotton*. Science Shop Wageningen University and Research Centre, Report 223
K Niinimäki and colleagues 2020. The environmental price of fast fashion. *Nature Reviews Earth Environment* 1 (2020): 189–200
R. Rathinamoorthy, 2019
B Henry and colleagues 2019. Microfibres from apparel and home textiles. *Science of The Total Environment* 652: 483–94
C Hofvenstam 2016. *Resurseffektiva Affärsmodeller – Stärkt Konkurrenskraft*. Stockholm: Kungl. Ingenjörsvetenskapsakademien
A ten Wolde, P Korneeva, 2019. *Circular Fashion Advocacy – A Strategy towards a Circular Fashion Industry in Europe*. www.ecopreneur.eu.

Problem dynamics lead to rising planetary pressures

In light of these current sustainability challenges, industry leaders and policymakers alike promote a shift from today's linear value chain to a circular economy, 'closing the loop' by reclaiming valuable materials and using them to make new valuable products. Making this shift demands a better dynamic understanding of how today's 'take–make–use–waste' fashion and textiles systems drive change in the planet-scale systems they are embedded within.

Three key factors drive the industry's increasing contribution to planetary pressures (**Table 2**, **Figure 5**)

- **The growth of textile production and use has exceeded industry expectations.** In a linear economy, the faster the industry grows, the greater the pressure on Earth's natural resources.

- **Consumer demand has escalated.** This economic push to make and sell more goods has driven a shift to lower quality and less durability, increasing problems of pollution and waste.

- **Today's fashion and textiles system is locked into unsustainable patterns of action.** The way businesses use resources and handle their material flows is shaped by many practical, technological, political and cultural aspects of global economies and local societies.

These factors have operated together to create a self-reinforcing loop in the fashion and textiles system, where production, consumption and waste leakages have grown in lock-step together.

These dynamics are currently pushing the system to an undesirable state – socially, ecologically and economically, and they have also contributed to a technical and institutional 'lock-in' situation that is far bigger than any one business can reverse.

Too often, businesses have kept their focus for action towards circularity narrowly on their own production activities and their immediate consumer markets.

In contrast, responsible businesses increasingly seek to widen their view of their responsibilities, going beyond the direct impacts of a product's life cycle to also consider the environmental impacts that are embodied in the international trade of product inputs and the consumption patterns of fashion users.

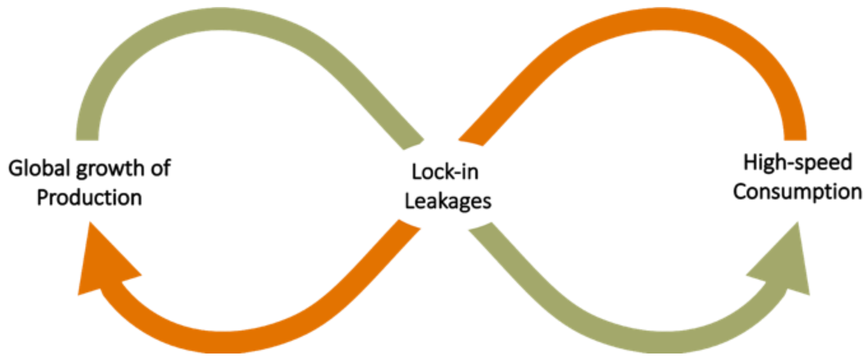


Figure 5 – The shift to circularity involves tackling problematic self-reinforcing dynamics. Global growth of production and high-speed consumption have contributed to a systemic lock-in that is not sustainable, to value chains with material leakages rather than a system that is restorative and regenerative by design.

Table 2 – The industry's contributions to planetary pressures[19]

Climate change: Fossil fuels are used for synthetic fibre production, and for energy use and transport of all fibres and textiles. Fibre production alone contributes 1% of global carbon emissions; the industry contributes up to 10%.
Biodiversity loss: Value-chain threats to life include soil degradation, deforestation (and CO_2 emissions), monoculture cultivation and introduced non-native species for crop fibres; and air, soil and water pollution for all fibres.
Land use change: Crop fibre production, cotton in particular, contributes to soil degradation, deforestation, desertification, and soil salinization creating landscapes where small-scale agriculture is no longer viable.
Freshwater use: Water is used in all manufacture. Fibre crops are sensitive to water availability. Intense irrigation leads to salinization and movement of crop areas, putting added pressure on freshwater use.
N and P flows: Chemically intensive agriculture is usually an inefficient use of nutrient elements, causing eutrophication and rising emissions of nitrous oxide, which is both a greenhouse gas and an ozone depleter.
Chemical pollution: Today's fibres and textiles use harmful substances including pesticides and other agrochemicals, dyes, and treatments (e.g., water- and stain-repellents), polluting through runoff and waste.

Challenging prospects lie ahead

Planetary changes are risk multipliers

Until recently, planet Earth has not been seen as an important player in the fashion and textiles system, but this is changing as planetary pressures mount. Any decline in the ecological resilience of one component increases the fragility of the whole resource system. And rising pressures are risk multipliers: climate change is a major threat to biodiversity. Both climate change and biodiversity loss are tightly linked to land and water use, nutrient flows and pollution, as **Table 2** indicates. Inaction on one front worsens conditions on the others.

These ecological demands have social dimensions that add to the challenge. Mitigation efforts and adaptations to a changing world will require new consumer and investor relationships as well as policy and regulatory changes. For instance, a shift to bio-based fibre production depends on availability of agricultural land, but competition for land resources is already intense as global demand also rises for food and biofuel crops. Global economic outlooks increasingly highlight the role of a changing environment in the slow-down of economies worldwide and as a source of risk to production and trade.[20] This is why the 2030 Agenda calls on business to act on *indivisible* global goals for reducing poverty, protecting ecosystems, promoting good governance and sustaining economic development.

Some businesses already recognise these global risks and are trying to make 'planet-positive' changes, reducing planetary pressures while also relieving global socioeconomic challenges.

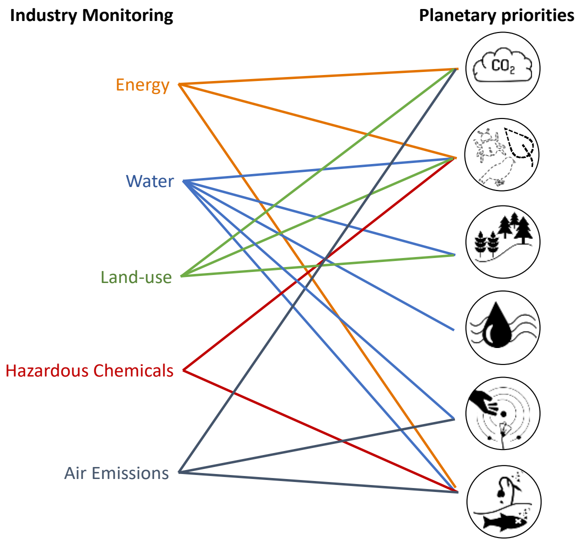


Figure 6 – Today's corporate sustainability efforts are cross-linked with the planetary priorities

[19] G Sandin and colleagues 2019. *Environmental impact of textile fibres – What we know and what we don't know.* The Fibre Bible Part 2, RISE, Gothenburg, Sweden; D Alama and colleagues 2016. *Biodiversity risks and opportunities in the apparel sector*. IUCN, Switzerland.

[20] World Bank 2020, *Global Economic Prospects 2020*; IMF 2019, *World Economic Outlook 2019*

A piecemeal picture is not enough for tracking resource flows and impacts in a changing world

Circular economy involves new kinds of business decisions about product inputs. Decisions now need to factor in ways to maintain Earth's regenerative capacity and restore the world's ecosystems, which provide essential stocks of natural capital and flows of life-supporting functions. Many clothing brands and companies already track their impacts and report on their operations using multiple environmental sustainability indicators, focused mainly on climate, energy use and polluting emissions – the issues where multilateral environmental policies have become national regulations.

The key carbon disclosure initiatives, notably those using the Greenhouse Gas Protocol, include reporting on water and land use.

Figure 6 shows how the main sustainability issues reported by clothing brands and companies in their corporate sustainability reports relate to the planetary priorities. The many crosslinks show the importance of an integrated approach to sustainability challenges. Current monitoring and reporting are an important foundation for tracking impacts, but at present each issue is reported individually, although efforts to address them impact multiple planetary priorities.

Efforts on one issue often have spill-over effects, both positive and negative, on other issues. Monitoring efforts tend not to reflect the geographic patterns of resource flows, so links between local actions and global impacts cannot be accurately assessed.

Assessing the fashion and textiles industry's overall contribution to global environmental problems and their solutions is extremely difficult. Sustainability schemes and standards are proliferating, but are not directly comparable (e.g. **Table 3** compares cotton certifications). Data gaps all along the value chain make quantitative impact assessments partial at best, and even potentially misleading. More fundamentally, there is no consensus about how to attribute social and ecological impacts to industry activities. The reality is that the evidence basis is incomplete for tracking the effects of resource use and assessing impacts. Despite these limitations, there is no doubt that it is time for the industry to step up its efforts to reduce current planetary pressures. The production, trade, consumption and disposal of clothes have consequences for *all* the planetary priorities. The best response strategy for industry is to widen collaboration for more resilient systems

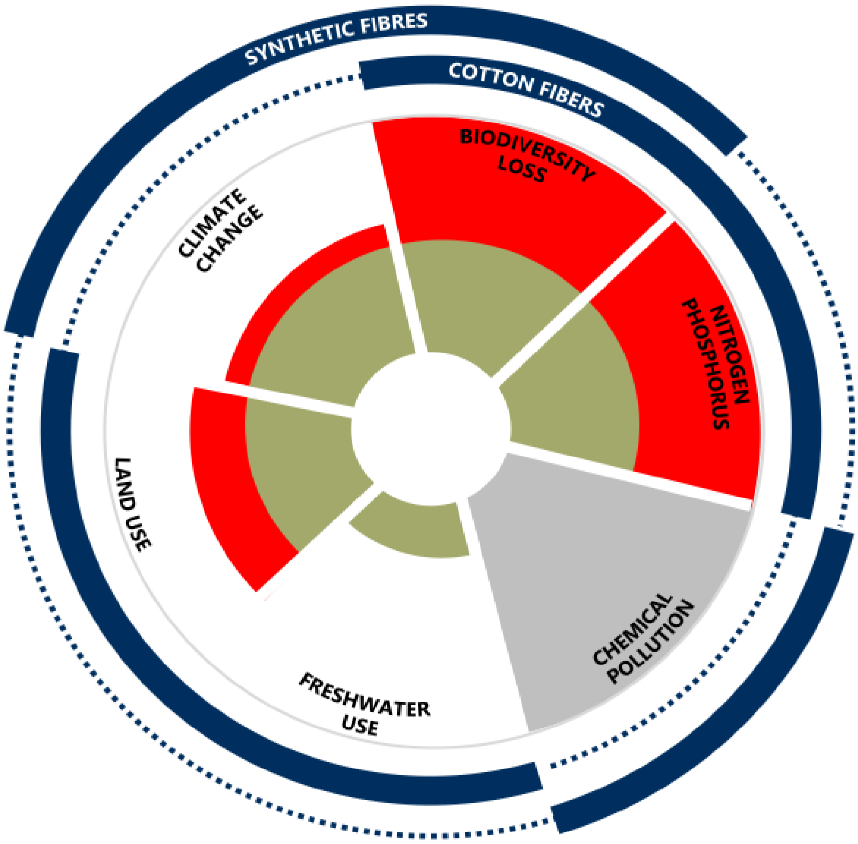


Figure 7 - Synthetic and natural fibres have different patterns of impacts on planetary pressures.

Table 3 – Comparing conventional cotton production and cotton standards on the planetary priorities.
Business decisions made about cotton sources can decrease the environmental pressures of cotton production.

Planetary pressures from conventional cotton production	BCI Better cotton	Organic cotton
Greenhouse gas emissions include CO_2 from soil tillage, soil organic matter degradation and fuel use on farms; nitrous oxide from degradation of N fertilisers applied to soil.	***Actions to reduce climate pressure:*** Educating producers about agricultural practices that support climate change mitigation and adaptation. ***Restrictions:*** None for any agricultural practices contributing to greenhouse gas emissions. ***Potential to reduce greenhouse emissions:*** **Very limited**	***Actions to reduce climate change pressure:*** CottonMadeinAfrica (CMiA) educates producers on making and using organic fertilisers to reduce greenhouse emissions. ***Restrictions:*** None for any agricultural practices contributing to greenhouse gas emissions. ***Potential to reduce greenhouse emissions:*** **Very limited**
Monoculture plantations have very low biodiversity. Biodiversity-rich areas are lost through expanding production, and degraded by water abstraction, irrigation, extensive use of fertilisers and pesticides, and GMO crops.	***Actions to reduce pressure on biodiversity:*** Educating producers about irrigation and use of fertilisers and pesticides. ***Restrictions:*** Producers must adopt a Water Stewardship Plan. They must not use pesticides listed in the Stockholm and Rotterdam Conventions nor Annexes of the Montreal Protocol. ***Potential to decrease biodiversity loss:*** **Limited**	***Actions to reduce pressure on biodiversity:*** Organic standards promote cultivation rotation, emphasize soil biodiversity. ***Restrictions:*** GMO and transgenic (Bt) cotton, and the use of synthetic pesticides and insecticides are not permitted. ***Potential to reduce biodiversity loss:*** **High**
Land use changes are driven by salinization from extensive irrigation; soil degradation from intense production; and land clearance for cotton plantations.	***Actions to decrease land-use change:*** Educating producers about irrigation. ***Restrictions:*** No restrictions to water use practices. Producers must adopt a Water Stewardship Plan. ***Potential to decrease land-use change:*** **Limited**	***Actions to decrease land-use change:*** CMiA educates producers in efficient rain-fed agriculture. ***Restrictions:*** CMiA and Global Organic Textile Standard (GOTS) do not allow irrigation. EU allows irrigation. CMiA does not allow cutting of primary forest for cotton. ***Potential to decrease land-use change:*** **High to Limited** (standard-dependent)
Cotton is a highly irrigated crop, often produced in semi-arid areas despite its high water demand. Over 50% of the world's cotton fields are irrigated (~70% of global production).	***Actions to decrease freshwater use:*** Educating producers about irrigation and agricultural water practices, to help protect and preserve local water resources. ***Restrictions:*** No restrictions on agricultural use of freshwater such as irrigation. Producers must adopt a Water Stewardship Plan. ***Potential to decrease freshwater use:*** **Limited**	***Actions to decrease freshwater use:*** CMiA trains producers on improved agricultural practices, water conservation. EU promotes responsible water use. ***Restrictions:*** CMiA and GOTS do not allow irrigation. EU allows irrigation. ***Potential to decrease freshwater use:*** **High to Limited** (standard-dependent)
Cotton production uses large amounts of fertiliser, affecting soil water retention and emitting nitrogenous gases to the atmosphere. N and P-rich effluents contribute to eutrophication and coastal anoxia ('dead zones').	***Actions to reduce N and P release:*** Educating producers on when and how to apply fertilisers to decrease leakages to the environment and groundwater. ***Restrictions:*** No quantitative restrictions for agricultural practices contributing to N and P flows. ***Potential to reduce N and P flows:*** **Significant** (practice-dependent)	***Actions to reduce N and P release:*** CMiA educates producers in fertiliser application techniques to preserve soil fertility and prevent runoff and leaching. ***Restrictions:*** Organic standards do not allow use of mineral nitrogen fertilisers; no quantitative restrictions on organic (recycled) N use. ***Potential to reduce N and P flows:*** **Significant** (practice-dependent)
Cotton production uses disproportionate amounts of pesticides, often with mixture effects. These threaten soil quality and biodiversity locally and result in polluting effluents and downstream harms.	***Actions to reduce pollution:*** Educating producers about agrochemicals application, requiring an Integrated Pest Management Programme. ***Restrictions:*** Producers must not use pesticides from the PIC and POPs Conventions or the Annexes of the Montreal Protocol. ***Potential to decrease pollution:*** **High**	***Actions to reduce pollution:*** CMiA educates producers in pesticide management. ***Restrictions:*** Organic standard producers must not use pesticides from the PIC and POPs Conventions or WHO class Ia/b. ***Potential to decrease pollution:*** **High**

The challenge of comparing synthetic and natural fibres

Comparison of cotton and synthetics shows how different fibres result in different planetary pressures (**Table 4)**. The production of both cotton and synthetic fibres indisputably has negative impacts on the environment but effects differ in place, timeframe and ecological and social consequences. Decisions about materials therefore have very different profiles of environmental impacts. For example, **Figure 7** shows the differences in the major impacts of cotton and synthetic fibres on the six planetary priorities. These trade-offs and the social and ecological spillovers of business decisions are always complex and cannot be captured in single metrics or simple formulas. But by mapping product impacts on all six planetary priorities, companies can have a much clearer and more complete picture of how their impacts stack up.

The large scale of today's cotton and synthetic fibre production means it not feasible to substitute one fibre for another, nor to replace them with a new innovative fibre in a near future. Cotton accounts for over four fifths of global natural fibre consumption. Synthetic fibres are included in approximately two thirds of textile fibre consumption.

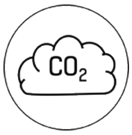
Cotton puts pressure on all planetary boundaries; climate, biodiversity loss, water and land use are the main issues. These global scale effects need attention as well as the local impacts of cultivation and consumption. The industry depends on cotton as the predominant natural fibre, yet industrial cotton production cannot function in the long run if ecosystems – at both local and global scales – are degraded and out of balance. Reducing the use of virgin cotton fibres can reduce pressure on all planetary priorities. Biodiverse production systems are more resilient to shocks and stresses, including to the effects of climate change. Climate change will have mixed effects on cotton. Higher temperatures might lead to increased yield in well-watered crops. But they will also potentially cause parched fields leading to less efficient water use, fruit loss, lower yield and reduced fibre length and quality. Decreased fibre lengths will have negative impacts on the quality of textile fabrics, hindering prolonged use of clothing.

Synthetic fibres, as a form of plastic manufactured mainly from crude oil, have a large and direct impact on climate change. Although synthetic fibres have become an indispensable part of everyday modern life, their environmental impacts are less well studied than for natural fibres, and data related to the other planetary priorities are scarcely reported. There is, however, clear evidence that synthetic fibres are now globally distributed in the environment. They can be seen as 'novel entities' from a planetary boundaries perspective. Synthetic fibre release not only reaches aquatic environments but also the soil, entering both the marine and the terrestrial food chains, including products meant for human consumption. In this way microfibre release is increasingly recognised as a threat to biodiversity.

Life cycle assessments (LCA) have limitations and gaps in their reflection of biophysical realities. LCA shows that there are simply not enough data (or reliable enough data) to really demonstrate the sustainability difference between any fibres[1]. Certifications of cotton can at best be referred to as 'less obviously bad'. Currently, recycled synthetic fibres are not made from used garments. Instead, the increased production is made from PET bottles, which increased demand for virgin material for producing PET bottles from crude oil.

Business plays a unique role as the producer of novel entities, some of which have become essential inputs in fashion textiles. Efforts focused on maintaining, restoring and even increasing biodiversity are key for limiting negative impacts of fibres. Decreasing microfiber from textiles benefit biodiversity which in the long run reduces the fashion industry´s impact on climate change. Efforts to reduce textile microfibres also reduce business risk from consumer pressure. Reducing waste and increase the residence time of garments is crucial to minimize the industry's environmental impacts.

Table 4 – Effects of cotton and synthetic fibre production on the planetary priorities. Note that additional impacts on the planetary priorities arise throughout the rest of the fashion value chain from fabric production to end-of-life.

Cotton	Planetary priority	Synthetic fibres
Cotton cultivation emits the greenhouse gases CO_2 and nitrous oxide, mainly from synthetic fertiliser use, the soil degradation of fertiliser and fossil fuel driven agricultural machinery. Organic cotton has a lower carbon footprint than cotton produced with agrochemicals.		Fossil fuel derived fibre production generates large amounts of CO_2 and other greenhouse gases. Biosynthetic fibres have potential to generate lower emissions because they use renewable feedstocks and take up CO_2 during the growing phase, but they require fertiliser use. Recycled synthetics generate much lower CO_2 emissions.
Conventional cotton production presents many threats to biodiversity, including deforestation and habitat loss, desertification, land degradation, over-exploitation, monoculture cultivation, invasive species, and pollution of air, water and soils. Organic cotton reduces some of these threats.		Fossil fuel extraction and transportation damage land and marine ecosystems. Factory emissions are widely regulated so biodiversity effects of fibre production are generally low. Crop-based biosynthetics risk having similar effects as cotton. Environmental releases of microparticles of synthetic fibres are an emerging concern.
Cotton cultivation has contributed to large-scale land degradation and deforestation. Intense irrigation causes soil salinization and leads to the geographic movement and expansion of cotton crop areas.		Land use effects are 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.
Conventional cotton cultivation depends on large-scale irrigation. Water is also used in fibre production and textile manufacturing. Some organic standards and certifications prohibit irrigation.		Water is used in fibre production and textile manufacturing processes, and many substances are added to the water. Production facilities that lack sufficient wastewater treatment contribute to water pollution, adding pressure to water resources in those regions.
Cotton cultivation uses large amounts of organic and synthetic fertilisers and releases large amounts to the environment. Around one fifth of applied N goes to the atmosphere or flows into water bodies. Only about one quarter of applied P is taken up by plants, leaving the rest bound in the soil or lost to water bodies.		Nutrient element flows are relatively low for synthetic fibre production. Nitrogen-containing gases are emitted during fossil fuel extraction and transportation. Crop-based biosynthetics risk having similar effects as cotton.
Conventional cotton cultivation uses large amounts of pesticides, which have ecosystem-wide effects. Cotton fibre production can involve the use of many substances that are potential hazards, such as dyes and other treatments. Organic cotton has a much lower chemical burden.		Synthetic fibre production uses a significant fraction of the global chemicals feedstock, including hundreds of substances that are potential risks to the environment. In well-regulated production facilities, these risks are kept low. Biosynthetics do not necessarily reduce the chemical burden compared with fossil fuel derived fibres. Risks of problematic effects arise with recycled synthetics. Microplastics from textile fibres are an emerging concern.

A circular economy can help reduce planetary pressures

Circular economy principles provide a way for the fashion industry to tackle planetary priorities and problem dynamics. Large scale and long-term perspectives are needed to avoid spillover effects and problem-shifting between technical and biological cycles

Circular economy and planetary boundaries are mutually supportive frameworks

The circular economy is a systemic approach to designing economic activity so that it benefits businesses, society and the environment. It recognises the importance of an economy that works effectively at all scales, right up to the planetary level.

A circular economy aims to maintain a continuous flow of goods and services in socially and ecologically restorative ways **(Figure 8).** It steadily decouples economic activities from environmental damage and the consumption of finite resources, and it is underpinned by a transition towards renewable materials and energy sources.

A circular economy is built on three principles:

- **Design out waste and pollution**
- **Keep products and materials in use**
- **Regenerate natural systems**

From a planetary priorities perspective, these principles are tightly linked. In the following sections, we outline how planetary priorities inform a focus on regeneration of the biosphere that underpins economic activities. We indicate changes that are needed in today's systems to reduce linear flows of resources, losses of materials and energy, and global pressures and risks, taking social and ecological dimensions into account.

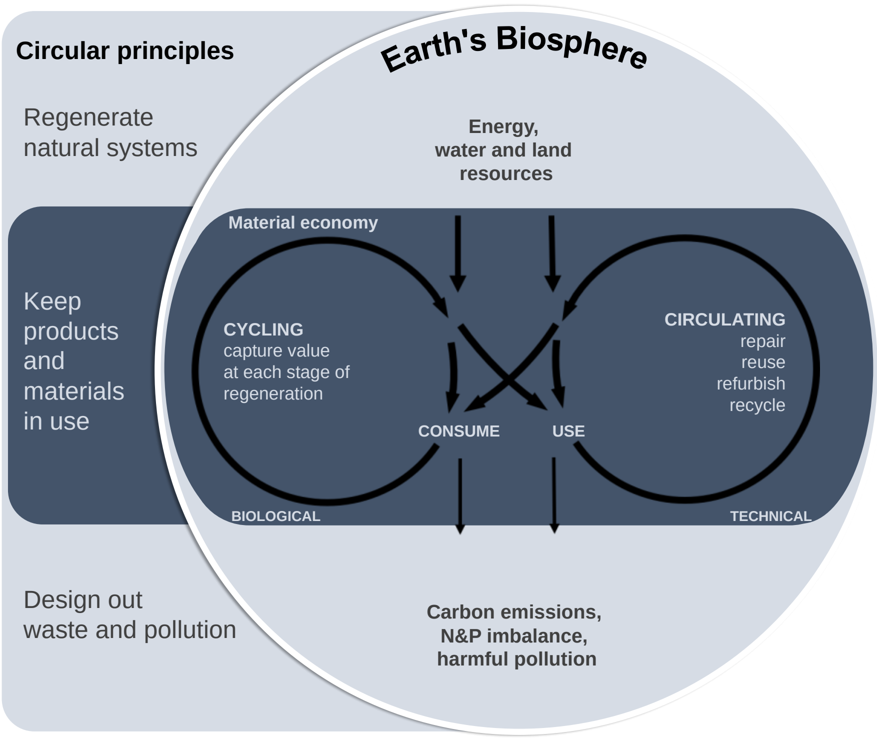


Figure 8 – Circular economy can reduce planetary pressures by changing resource consumption and use. The biological loop (left hand side in this simplified diagram) focuses on how renewable resources are consumed, and the technical loop (right hand side) provides options for managing resource use and maintaining their stocks.

It is useful to distinguish between technical and biological cycles in the 'value circle' of a circular economy:

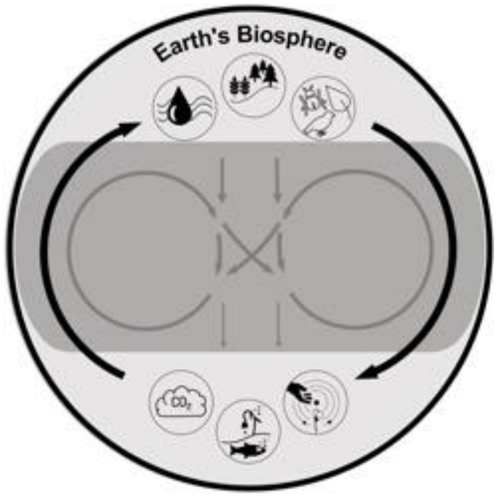
- **Biological cycles regenerate Earth's living systems.** These provide renewable resources to underpin consumption, and regulate the often invisible environmental processes that maintain Earth's stability and resilience. A circular economy manages the flows of renewable materials. For example, when food, fibres and other biologically based materials are used, they are then fed back into healthy ecosystems through processes such as composting and anaerobic digestion. Circular systems make effective use of biologically-based materials by encouraging many different uses before nutrients are returned to natural systems.

- **Technical cycles recover and restore products, components, and materials.** The world's material stocks can be managed through strategies including reuse, repair, remanufacture, and (in the last resort) recycling. In a circular economy, resource stocks are managed by circulating materials in use at the highest value possible.

Of course, the two cycles are not actually separate from each other. It is better to think of them as interacting dynamic systems, rather like adaptive cycles (**Appendix A**). In today's human-modified world, technologies play an essential role in ensuring that the world's living resources can flow through biological cycles. And at the same time, ecological functioning places constraints on the technical cycles, not least through the provision and associated climate impacts of the energy that is required for material recovery, repurposing and recycling.

The circular economy concept and the planetary boundaries framework capture different insights about how the world's systems work. Bringing the two concepts together helps understand how the material economy works within the context of the larger Earth system.

The circular economy concept and the planetary boundaries framework can fit well together, giving important context to each other. They jointly show the main challenges and constraints that today's economy must recognise if people's wellbeing is to be maintained.



Circular economy aims to be regenerative. Planetary boundaries explain what needs to be regenerated.

Both circular economy and planetary boundaries emphasize that the material economy is part of Earth's biosphere.

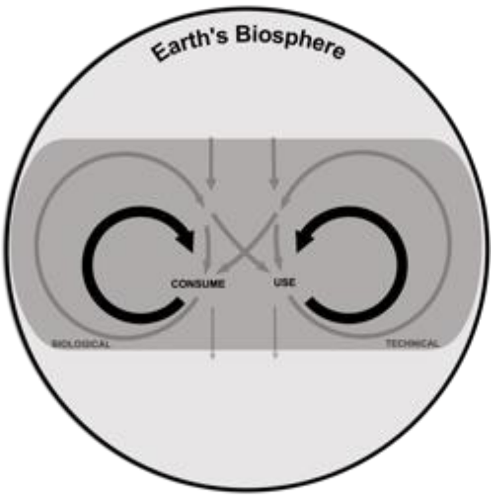
The planetary boundaries framework gives an Earth system rationale for a restorative and regenerative circular economy and characterizes its global 'safe operating space'. The framework highlights how human activities are currently undermining the stability and resilience of Earth's climate and biosphere on multiple fronts.

All life – and *all* economic activities – are supported through the Earth system's functioning natural cycles: the water cycle, and the biogeochemical cycles of carbon, nitrogen, phosphorus and other elements. The global viewpoint of the planetary boundaries expands the usual short-term perspectives of the economy by drawing attention to the shifting dynamics of these cycles and the longer-term environmental impacts of material flows within the economy.

Circular economy is based on the fact that economic activities depend on Earth's regenerative capacities. It calls for business decision-makers to take natural resource consumption, use and waste into account. The economic exploitation and speed of consumption of renewable resources must respect the planet's resource-regenerative capacities. Incorporating insights from Earth system science can help shift to a system designed for positive impact, where innovations explicitly consider how businesses can contribute to strengthening Earth resilience with positive effects on planetary boundaries. Cuts in CO_2 emissions are urgently needed to tackle climate change, but the planetary boundaries framework highlights that climate change mitigation efforts should also protect and restore biodiversity, not undermine it.

Regenerative cultivation and sourcing, for instance, can ease many planetary pressures at once. It can support climate change mitigation and adaptation by capturing carbon into the soil's organic matter. This improves the soil's physical structure and nurtures beneficial microbes, which leads to a cascade of other benefits: better water retention, soil regeneration, and reduced reliance on synthetic fertilisers. It also supports biodiversity through crop diversity and reduction of noxious chemicals.

How regenerative natural systems are built up in practice will depend on the local context, the scale of the initiative, and many other factors. However, by considering all the planetary priorities together, all approaches can ensure that the resource producer is part of a mutually supportive planetary ecosystem.



Circular economy is a system change to 'close the loop' of linear value chains. Planetary boundaries show how much change is needed and how efforts can add up rather than undermine each other.

Both circular economy and planetary boundaries rely on processes of system change.

Circular economy provides the economic logic for closing the material loops of linear value chains, reducing the need for new raw resources to be extracted from living organisms, landscapes, watersheds and the oceans.

Closing the loop involves preserving basic materials.

Opportunities to close these loops are driven by principles of value creation. Value can be created by keeping products in use, and by maximising their utilisation rate (e.g. multiple users and repairing). Value can also be created by circling for longer, designing products and systems for reuse generating revenues from additional life cycles of that product.

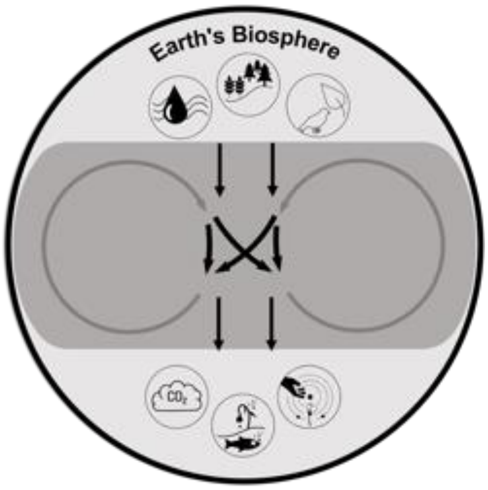
Continued value creation can be assured by designs and inputs that are non-toxic and separable ensure that it is easy and safe to separate components for reuse and materials for recycling.

Moves towards bioeconomy and increasing use of biobased materials present complex trade-offs between the technological and biological loops. In the biological loop, the return of biological materials to the biosphere will not necessarily advance recovery or restoration. It matters for sustainability when, where and how they are brought back to the biosphere. For example, eutrophication is a direct outcome of an increased level of biological nutrients. It is important to recognise the role of Earth's intrinsic dynamics, such as its seasonal changes, in enabling natural metabolic cycling.

In the technical loop, energy inputs are unavoidably needed for circulating products and materials in the technical loop. Circular economy aims to shift to biobased materials and use renewable energy to power the economy. But this shift in the biological loop from fossil-based to renewable energy and feedstocks also has environmental consequences, especially with regard to societies' multiple demands on landscapes and watersheds. The planetary boundaries perspective highlights the fact that resources need to be preserved, not just used, for circular economy to be part of a sustainable and resilient world: many of the pressures on the planetary boundaries are driven by human activities that consume natural resources and energy.

The planetary boundaries perspective highlights the importance considering the systemic importance of landscapes and watersheds and recognizing their roles as carbon sources and sinks, biodiversity and biogeochemical flows as well as seeing them as sources of natural resource materials.

Most economic decision-making does not yet take these aspects into account. The planetary boundaries perspective highlights that the size of the industry matters for sustainability, not only its efficiency – a quantitative shift is needed to enable the economy's loops to become closed. As human disturbances to the Earth system's functioning are already beyond safe limits, absolute reductions in total material flows and energy use needs to be prioritised.



A shift to a circular economy rethinks waste as resources. Planetary boundaries track Earth's capacity to provide resources and absorb waste and pollution.

Together, circular economy and planetary boundaries enable decision-making to tackle externalised environmental harms.

Circular economy aims at fostering system effectiveness by designing out waste and pollution. Prevention of waste requires innovative ways of designing and producing products. In addition, recycling is about fundamentally rethinking about materials that have previously been considered waste as a resource instead. Circular economy therefore requires designing system-wide shifts to reduce flows of resources that generate losses of materials, energy and economic value.

Currently, materials are lost throughout the textiles and fashion value chain, at every step from resource extraction through production of fibres, textiles and garments, to the end-of-life stage. All of these leakages bear environmental impacts, and many of these impacts are negative externalities: their costs are not covered by the producer but are borne elsewhere in society. The planetary boundaries framework points to the need for decision-making about resources, waste and pollution to recognise their relationship to global environmental pressures and relieve mounting risks.

The multidimensional planetary boundaries framework provides global environmental criteria for a more systemic analysis of negative and positive externalities of the circular economy concept, at all scales from the production site up to the planetary level (including effects that may play out over long timeframes, affecting future generations).

Once again, it is vital to bear in mind that the planetary boundaries processes are linked, so pressures on any one boundary have cascading impacts in the Earth system. For example, land-system change is a major direct driver of biodiversity loss and climate change. In addition, by changing the water cycle, impacts arise on biodiversity, water availability, climate conditions and land cover in places far away from the location of the initial change. In this way, choices about material production and sources can have different and unexpected environmental consequences. Translating the Earth system metrics of the planetary boundaries framework provides a basis for prioritising activities in a circular economy and also for setting benchmarks for circularity. By assessing all six planetary priorities, companies have a much clearer and more complete picture of how their impacts stack up.

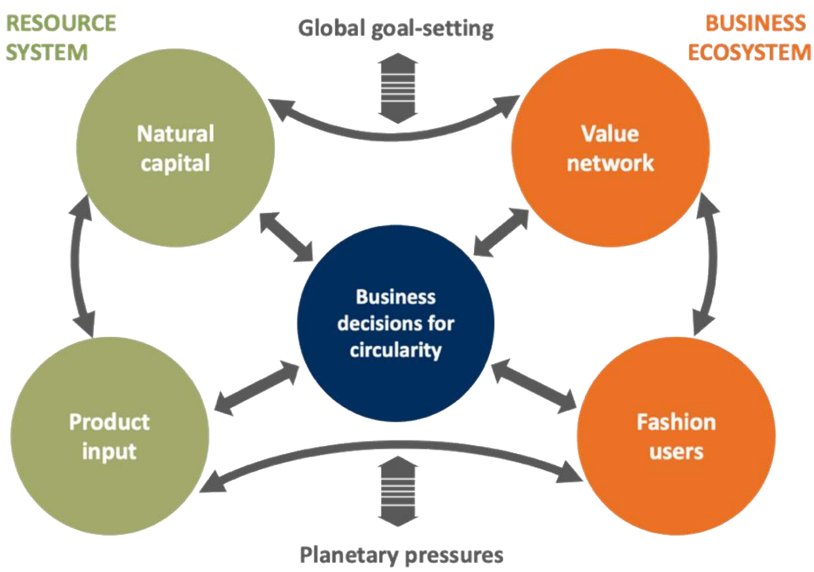


Figure 9 – Business decision-making plays a central role in shaping interactions between Earth's natural resources and today's worldwide value networks.

Closing a loop or (re)connecting global ecosystems?

A critical step towards sustainability involves making the necessary shift to a circular economy – one that not only closes material cycles but also responds strategically to planetary pressures. This widens the scope of business decision-making and action **(Figure 9**). Too often, businesses focus too closely on their own supply chain, making near-term decisions about product inputs and sales strategies (represented as the links along the bottom part of the framework in the figure). But a transition to a circular economy requires rethinking how circular fashion business decisions influence the dynamic connections between the wider business ecosystem and Earth's resource system, in their global contexts.

Business decisions are part of a bigger and interconnected social-ecological system, where natural capital supplies and demands are crosslinked with the many different parties involved in a circular value network. Seeing the textiles and fashion system this way helps businesses to be prepared for the global
opportunities and risks of a transition to a circular economy.

On the biophysical side, business decision-making plays a vital role in shifting to restorative and regenerative systems by protecting Earth's resource system.

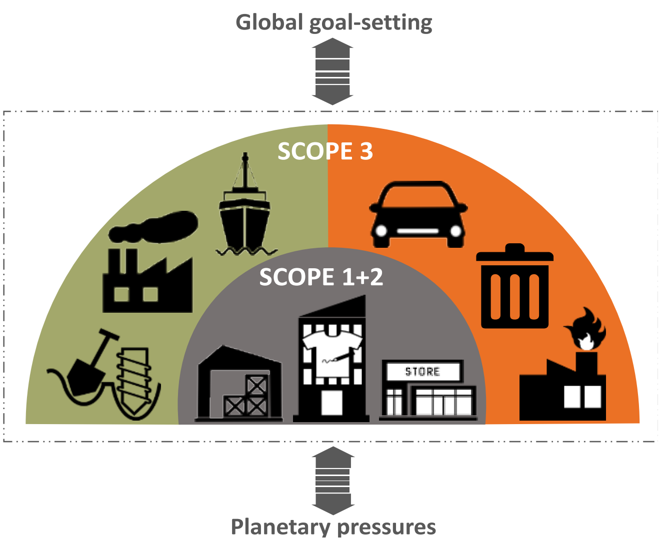


Figure 10 – Responding to planetary pressures requires an extended scope of action. The 'scopes' shown are based on the Greenhouse Gas Protocol's corporate value chain accounting and reporting standards. Scopes 1+2 cover onsite actvities and energy use. Scope 3 covers purchased goods and services, use and end of life phases.

This means maintaining natural capital (and where needed, rehabilitating it) to ensure that a stable climate and a resilient biosphere can continue to supply societies with the materials, land, water and energy resources they need. On the social side, circular economy depends on the fundamental redesign of products, material streams, economic systems and social habits. Business decision-making plays a vital role for mobilizing fashion users and many other actors in wider society to engage in the joint innovation, experimentation and coordination that is needed for a shift to a circular economy.

Extending the scope of action this far beyond the direct value-chain links between production inputs and the sales floor entails scaling out to include wider social and economic dynamics of the global business ecosystem, including the cultural factors that motivate fashion users worldwide. It also entails scaling up to recognize and respect both the biophysical dynamics of planetary pressures and society's global goals for sustainability.

Many of the levers for a shift to circularity extend outside what most businesses think of as today's value chain (**Figure 10**). For instance, non-business actors steer basic research, raw materials provisioning, infrastructures and policies that influence action. Individual choices and cultural changes shape people's fashion uses, views and habits. In the climate mitigation context, the greenhouse emissions caused by these indirect impacts in the value chain are called 'scope 3' emissions. Many businesses that disclose their emissions and report on their climate action are now looking more closely upstream and downstream into their value chain to assess the full environmental impact of their operations. Because of this, the term 'scope 3' is also being used to refer to other kinds of indirect environmental impacts of the value chain.

The environmental consequences of scope 3 factors are not under a company's direct control, but the business may nevertheless be able to drive changes in the activities that result in environmental harms, and remove obstacles to a shift to circularity.

Depending on its resources and commitment, a fashion business may be able to contribute to multiple levers for accelerated change to a circular economy. Viewing these factors from a planetary social-ecological perspective and tracing how these factors interact helps to pinpoint where action can be targeted.

Recycling is not enough – it takes rethinking to reach a circular economy

The fashion and textiles industry identifies recycling of textile waste as an important economic and environmental opportunity, but effective recycling needs to be aimed at the main problem dynamics, otherwise 'closing the loop' does not actually work.

1. **Material leakages need to be minimised in the value chain**. Effective recycling extends beyond production waste to also include post-consumer waste, so the recycling rate (i.e. collection of used garments) needs to be much higher than it currently is to ensure the flow of resources through the system.

2. **Material growth of the industry needs to be constrained.** Today's need for virgin resources is driven by the interplay of production growth and the increased speed of consumption so for now, recycling can decouple economic growth from raw resources. Relative decoupling only reduces the share of primary resources in the total product. Absolute decoupling from raw materials (and their biophysical impacts) is what counts for sustainability, but it cannot happen if the global production rate of textile fibres is growing.

3. **Consumers play a vital role**, by bringing old or unused items back to recycling. But to proactively prevent waste generation, other efforts should also be prioritised and used together with recycling. Consumers having fewer clothes in their wardrobes and using them for longer, promoting smarter product use and extending the lifespan of products and their parts are all 'levers' for shifting to circular systems.

Recycling is actually a linear end-of-pipe behaviour. A systems rethink considers more than just material flows. A proactive approach would decrease the need for raw resources, lower energy demands and reduce the many environmental impacts of clothing. Efficiency through recycling helps with 'doing things right', but it does not guarantee that the industry is doing the right things, ecologically or socially. Developing quality and value without significant additional material requires attention to many more aspects of how clothes and their component materials are used, not just how they are produced.

What does this mean for the fashion and textiles industry?

Circular economy is full of complex cross-scale interactions. Rapid and concerted action is needed on planetary priorities, but these interactions influence intended outcomes. The industry can align action targets to support each other rather than undermine efforts to reduce planetary pressures

A planet-aware framework for business action towards circular economy

In this report, we have shown that circularity for fashion and textiles involves more than closing the industry's current linear supply chain into a loop. The industry needs to fundamentally rethink its position in a complex socially and ecologically cross-linked value network.

Similarly, tackling the industry's planetary pressures involves more than increasing recycling rates or choosing different fibres that have lower impacts on some environmental indicators. A circular economy that respects planetary boundaries fundamentally rethinks the dynamic links between the resource system that is embedded in Earth's biosphere and the whole value network that determines the industry's scale of production, the pace of consumption and the possibilities for avoiding and recovering material leakages.

In this section, we show how planetary priorities and circular economy principles can be combined in a framework for business action for circularity. **Figure 11** shows a framework for viewing the links between business decision-making and society's longer term global goals for people, planet and prosperity. Within this global context, the fashion and textiles system links the resource system that supports production and the globally networked business ecosystem that enables consumption and generates value.

This nested framework helps to set out steps for a circular economy that tackles planetary priorities and builds in resilience to global changes.

Global goals set the context for action

International environmental commitments that aim to tackle planetary pressures provide important long term, global-scale context for business action in the transition to circular economy. The objectives articulated in these multilateral environmental agreements are framed as desired future conditions, extending strategic timeframes well beyond just the coming decade. These objectives are informed and monitored by expert science and policy communities (as outlined in **Table 1**, p.10), and nations have agreed that achieving these objectives contributes to a sustainable and resilient future. With these objectives in mind, concrete global environmental goals can be set out for each of the six planetary priorities. Keeping these long-term global goals in mind at the same time helps avoid the situation where near-term actions on one front undermine progress on other planetary priorities.

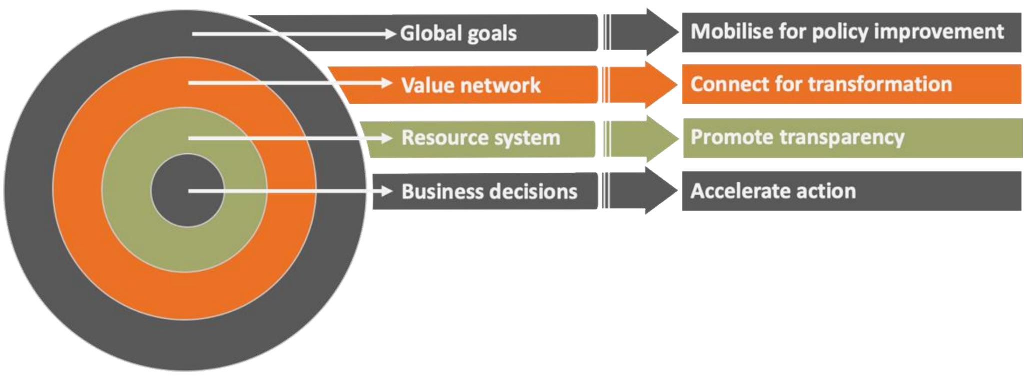


Figure 11 – Planet-aware business action for a sustainable and resilient circular economy

In brief:

- For ***climate change***, the global goal is to achieve carbon neutrality by 2050. This comes from the Paris Agreement's aspirational goal to keep global warming within 1.5°C compared to pre-industrial levels.

- For ***biodiversity loss***, the global goal is to bring 30% of the world under conservation protection that safeguards human rights. This places the world on a regenerative trajectory, not one of managed decline. This goal is aligned with the Convention on Biological Diversity's 2050 Vision of a world where biodiversity is conserved, restored, valued and wisely used to sustain a healthy planet and deliver benefits essential for all people.

- For ***land use***, the global goal is to restore 20% of the world's land area to an ecologically resilient state. This contributes to achieving the Convention on Biological Diversity's 2050 Vision and the prevention of land degradation and desertification. Done wisely it can also contribute to climate change mitigation and the avoidance of disrupted hydrological cycles in neighbouring regions.

- For ***water use,*** the global goal is to maintain total freshwater withdrawals below 40% of renewable supplies in all watersheds. This avoids high water stress, mitigates rising risks of water scarcity, and helps to avoid spillover effects of disrupted hydrological cycles to other regions.

  Water is not governed by any single global convention but there is widespread science and policy consensus that the steep trend in global freshwater use seen since the 1950s must be halted and where possible reversed in the coming decades.

- For ***chemical pollution*****,** applying the principles of prevention at source, polluter pays and precaution all contribute to the shift to fully circular and restorative production systems. Various multilateral conventions also specify restrictions or bans on specific substances and applications. For a circular economy to contribute to a sustainable and resilient world, the global goal must be framed in terms of avoiding pollution problems in the first place, rather than in terms of tackling downstream problems when they are already severe harms.

- For ***N & P flows***, the global goal is to improve long-term full-chain nutrient use efficiency for all bio-based resource production by 50%. As for water, there is no single global agreement on nutrient element management, but there is strong consensus that the steep problematic trends of inefficient use, environmental leakage and socially costly externalities must be halted. Ecological remediation of N and P over-enrichment is a very long-term and highly uncertain process. In short, the environmental release of N and P is an unaffordable waste of natural resources.

Key sources and links

- UN Framework Convention on Climate Change 2015. Paris Agreement. FCCC/CP/2015/10, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement; IPCC 2018. Global Warming of 1.5°C. IPCC Special Report, eds V Masson-Delmotte and colleagues.
- UN Convention on Biological Diversity 2011. Strategic Plan 2011-2020. https://www.cbd.int/sp/elements; GM Mace and colleagues 2018. Aiming higher to bend the curve of biodiversity loss. Nature Sustainability 1: 448-451; UN CBD 2019. The post-2020 biodiversity framework: targets, indicators and measurability implications at the global and national level. OECD Information paper to the 23rd meeting of the CBD Subsidiary Body on Scientific, Technical and Technological Advice, Montreal, Canada, CBD/SBSTTA/23/INF/3.
- UN Department of Economic and Social Affairs 2020. Sustainable Development – SDG 15. https://sdgs.un.org/goals/goal15; IPCC 2020. Summary for Policymakers: IPCC Special Report on Climate Change and Land, Geneva, Switzerland; Science for Environment Policy 2016. No net land take by 2050? Future Brief 14 for EC DG Environment. Science Communication Unit, UWE, Bristol.
- UN Department of Economic and Social Affairs 2020. Sustainable Development – SDG 6. https://sdgs.un.org/goals/goal6; Global Water Systems Project and World Bank 2020. Navigating the water challenges of the 21st century. https://water-future.org/what-we-do/compass; Our World in Data 2020. Water use and stress. https://ourworldindata.org/water-use-stress, accessed 20 Dec 2020; P Keys and colleagues 2019. Invisible water security: Moisture recycling and water resilience. Water Security 8: 100046.
- At European level these principles are encoded in the Treaty of the Functioning of the European Union, Part 3, XX – Environment, Article 191, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:12016E191&from=EN (accessed 20 Dec 2020); M MacLeod and colleagues 2014. Identifying chemicals that are planetary boundary threats. Environmental Science & Technology 48, 11057−11063.
- Global Partnership for Nutrient Management, https://sustainabledevelopment.un.org/partnership/?p=7426; UN Environment Assembly 2019. Sustainable Nitrogen Management. Decision UNEP/EA.4/L.16, www.informea.org/en/decision/sustainable-nitrogen-management; MA Sutton and colleagues 2013. Our Nutrient World: Global Overview of Nutrient Management. GPNM and International Nitrogen Initiative and the Centre for Ecology and Hydrology, Edinburgh.

In today's globalised industry, however, the twin challenge of shifting to circularity and tackling the problematic trends on the planetary priorities is far bigger than any one business can resolve on its own. Current regulations and legislation can also hamper the transition to circular economy. There are conflicts between existing policy objectives, so better integration and coherence of environmental, social and economic policies are needed. Production systems, trade networks, valuable markets and investments have created 'lock-in' situations that are difficult and costly to exit. In short, realising a circular economy and achieving the long-term global goals above requires system-wide change.

To release these barriers, the fashion and textiles industry needs to mobilise and coordinate efforts for a better policy landscape. The industry can call on governments for greater clarity and coherence in policies on climate, biodiversity, resources and waste. International cooperation conditions play a vital role for both a circular economy and achieving global environmental objectives. Policy improvements can help to reduce the risks of perverse incentives and maladaptive responses (such as subsidies that fail to take environmental externalities into account). Better policies can also provide the long-term market signals needed for investments in infrastructure changes and innovations as the industry navigates the shift to a circular economy and a sustainable and resilient future.

Resource systems and value networks expand the scopes and scales of action

The natural resource systems and value networks in which the fashion and textiles industry operates are socially and ecologically interdependent. In the resource system, the material inputs used to produce and sell fashion and textiles are also drivers of global changes that determine the stocks and flows of natural capital that ultimately sustain all other value-generating social activities. In the business ecosystem, satisfying the buyers and users of fashion can no longer be the endpoint of the industry's responsibilities because fashion users are a crucial link in the extended network needed for the value of materials to be fully utilised.

This multi-scale system-wide interdependence means that environmental and economic risks can propagate quickly and with a great geographic spread. Equally, action to navigate the transition to a circular economy can also propagate fast once the priorities and principles for action are agreed.[21]

Integrating planetary priorities and circular economy principles is a social, ecological and economic integration. Equipping the industry to benefit as much as possible in the shift to a planet-aware circular economy requires both an expanded scope of action and an extended responsibility.

Socially, this means that the industry first needs to take special care for areas of existing stress. The world already has many hotspots of biodiversity loss, land conflicts, water scarcity, intense pollution and climate risks, including areas where people are experiencing multiple pressures playing out at the same time[22]. As systems shift away from fossil fuel use to renewable sources of materials and energy, the industry needs to operate with regenerative crop cultivation practices that help assure people's wellbeing all through the value network. And the industry needs to recognise that regenerative systems are biocultural systems; there are inextricable links between people's lifestyles and their use of living nature. This is particularly important when Indigenous, traditional and local lifeways, identities, knowledge and sustainable practices are threatened (to some extent, these biocultural identities are protected under international law[23]). But equally, a deeper knowledge of the tight links between culture and environmental effects can play a vital role in motivating fashion customers to change their habits as part of a regenerative and restorative economy.

Ecologically, as the industry rethinks its material choices for circular performance, it needs to recognise that absolute impacts count. It is not enough to make marginal improvements and relative decoupling if emissions and waste are not actually reducing overall. The industry also needs to acknowledge that life-cycle impacts on the planetary priorities cannot be traded off against each other as they all contribute to degrading or depleting natural capital. In the interconnected world, impacts cascade through ecosystems. Landscapes are connected to the oceans and atmosphere, making pollution a large-scale problem not just a local one. Water flows underground, in the atmosphere and through vegetation, not just in rivers and lakes, making wise decisions about resource extraction a regional challenge not just a local one. The industry also needs to address the fact that these accumulating and interacting damages to the environment (and to public health) are not adequately reflected in the prices of raw materials or products. Unsustainable fashion products have been kept cheap as a result, and ecological externalities now make a problematic market barrier to the sale of sustainable fashion products and the transition to circular economy. Making product choices with the planetary priorities in mind and designing out waste and pollution help to reduce this barrier.

Economically, the expanded scopes of action and the extended responsibilities that arise with a shift to circular economy mean that the industry needs to reassess its activities all along its value chains. The industry needs to reposition its activities to fit into adaptive biological and technical cycles of circularity. For instance, retailers need to rethink who their 'customers' are, because they are no longer just the first buyers of garments, but the whole web of organisations that handle materials and provide services for a regenerative and restorative system. The industry needs better ways of assessing and reporting its impacts, in order for materials to be kept in use and for value to continue to be generated through multiple use cycles. After all, 'scope 3' impacts currently span across the world. Effective responses to these indirect impacts are often a question of where, when and how actions are taken rather than how much effort or money is deployed. A particular challenge is in how to assess needs and evaluate industry responses to longer term and larger-scale changes. The current focus on direct impacts is too narrow, and contributes to the loss of resilience of the industry's resource systems.

Cross-scale governance is a way to refer to the many interacting ways that societies can steer themselves through the transition to a planet-aware circular economy. The transition will require decisions about shifts in resource generation, investment, innovation, production, distribution and consumption. In short, many of industry's current connections need to be reconfigured for a system-wide transformation. The transition can become an opportunity for more environmentally appropriate and socially equitable action – but this will require new ways to manage the diverse and interconnected organisations and interests that make up the global fashion and textiles system.

Improved system-wide transparency is definitely needed to enable this reconfiguration and effective functioning of the new circular economy systems. At the moment, the fashion and textile industry's worldwide connectivity has resulted in a situation where transparency and mutual accountability often lacking. Information about the composition and sourcing of

[21] EP100 and RE100 are examples of coalitions for best-practice sharing and industry-wide learning for energy system transformation.

[22] UN Environment 2019. *Global Environment Outlook – GEO-6: Healthy Planet, Healthy People.* Nairobi, Kenya

[23] For example, in the 1948 UN Universal Declaration on Human Rights, the 1972 UNESCO World Heritage Convention and the 1992 UN Convention on Biological Diversity.

materials and products is lacking or difficult to obtain, even within the industry. The industry needs to track what is in their products, at every step in the loops of circularity from manufacture to reuse and recycling.

Improved transparency is also vital in ensuring that the shift to circular economy is a socially just transition. The impacts of the linked planetary priorities are escalating worldwide, while the pressures are still growing. Enabling informed decisions to be made all along the value chain can ensure that business action reduces the pressures and helps restore and rehabilitate the parts of the world where social and ecological impacts are already severe.

Planet-aware targets for business action *now*

By setting action targets on the six planetary priorities now, individual businesses can ensure their circular economy efforts reduce pressures by 2030, and also contribute to the system-wide change across the industry that is needed to meet global goals for the longer term.

In brief, a planet-aware programme of action to 2030:

- For ***climate change***, achieving carbon neutrality by 2050 requires 8% or higher reductions of CO_2 emissions year-on-year starting now. Faster reductions increase the likelihood of climate stabilization at lower global temperatures and reduce the risks of the most severe impacts on societies and nature. This required emissions reduction rate is a globally assessed number, interpreting the global warming goals as a flat-rate global carbon budget and treating all emission sources as equally valid. The world's nations do not all agree that this is a sound basis for fair and equitable burden sharing.

- For ***biodiversity loss***, there is no global budget of living nature to share out among sectors. Instead, the target is like a statement of operations, ensuring no further net loss of biological diversity and instead aiming for net gains each year in the coming decade. Unavoidable ecosystem damages resulting from the industry's activities need to be balanced by at least equivalent protections to habitats, species populations and the genetic 'library of life' – and improvements should be sought where possible. Reforestation plays a particularly important role in providing both biodiversity and climate benefits, but all 'no net loss' assessments should reflect that today's ecosystems also need to be resilient to committed climate changes. For this, comprehensive efforts are needed for fuller assessment the effects of industry on life on land, both above and below ground, and on life below water.

- For ***land use***, deforestation and other land degradation associated with fibre and feedstock production needs to halt, starting now. The fraction of crop production that avoids land degradation and mitigates climate change (such as through agroecology and sustainable intensification approaches) needs to triple or more by 2030 – and this is both feasible and necessary. As the industry's transition to circular economy requires a shift to bio-based energy and fibres, the currently small fraction of material production provided by regenerative and 'climate-smart' agriculture needs to increase sharply.

- For ***water use,*** the action target is to reduce freshwater abstraction and consumptive use by at least 30% by 2030. This generic target is based on what is required to halt the past rises in use and help protect watersheds worldwide from water stress. It reduces direct water security risks to brands and recognises the shared nature of water. Individual companies obviously need to attend to what nature and people need locally (reflected in SDG Targets 6.2-6.6), recognizing that the water cycle involves much more than just the water that flows out of taps and through pipes.

- For ***chemical pollution*****,** the target has three components. First is to prevent all environmental release of chemicals of high concern, all along the value chain. Current best available practices (like the EU's REACH regulation) should be followed. The next component targets bio-based fibre and energy production, reducing the environmental use of harmful pesticides by 50%. Countries are so far failing to meet SDG Target 12.4 on environmentally sound management of chemicals and wastes, and businesses worldwide play a critical role in tackling this situation. The third component is to prevent waste generation, by rapidly ramping up redesign, reuse and recycling. This is a systemic rather than a quantitative target, hinging on the establishment of transparency all along the value chain.

- For ***N & P flows***, the target is quite simply to comply with local air and water quality targets and policy requirements along the industry's supply chain and everywhere that fashion businesses operate. Environmental problems from excess fertilizer application and nutrient element leakage into the environment are severe and projected to worsen, and many countries are so far failing to meet SDG Targets for good air and water quality, but there is not yet a comprehensive global scientific assessment for generic quantified target-setting. Brands can nevertheless take action now.

Key sources and links

- N Höhne and colleagues 2020. Emissions: World has four times the work or one-third of the time. Nature 579: 25-28; IPCC 2018 Global Warming of 1.5°C. IPCC Special Report, eds V Masson-Delmotte and colleagues; J Rockström and colleagues 2017. A roadmap for rapid decarbonization. Science 355: 1269-1271
- Secretariat of the Convention on Biological Diversity 2020. Global Biodiversity Outlook 5. Montreal. https://www.cbd.int/gbo/gbo5/publication/gbo-5-en.pdf; M Weissgerber and colleagues 2019. Biodiversity offsetting: Certainty of the net loss but uncertainty of the net gain. Biological Conservation 237: 200-208; S Diaz and colleagues 2020. Set ambitious goals for biodiversity and sustainability. Science 370: 411-413
- UN DESA 2020. Sustainable Development – SDG 15, https://sdgs.un.org/goals/goal15; IPCC 2020. IPCC Special Report on Climate Change and Land, Geneva, Switzerland; FABLE 2019. Pathways to sustainable land-use and food systems. IIASA, Laxenburg and SDSN, Paris; S Wolff and colleagues 2018. Meeting global land restoration and protection targets. Global Environmental Change 52: 259-272; FAO 2019. Climate-smart agriculture and the Sustainable Development Goals: Mapping interlinkages, synergies and trade-offs and guidelines for integrated implementation. Food and Agriculture Organization, Rome; B Campbell and colleagues 2014. Sustainable intensification: What is its role in climate smart agriculture? COSUST 8: 39-43; Global Alliance for Climate Smart Agriculture, www.fao.org/gacsa
- CEO Water Mandate 2017. Exploring the case for context-based water targets. CDP, The Nature Conservancy, Pacific Institute, WRI and WWF International. UN DESA 2020. Sustainable Development – SDG 6 https://sdgs.un.org/goals/goal6
- UN Environment 2019. Global Chemicals Outlook II. Nairobi, Kenya. UN DESA 2020. Sustainable Development – SDG 12, https://sdgs.un.org/goals/goal12; EC 2006. Registration, Evaluation, Authorisation and Restriction of Chemicals, Reg EC 1907/2006 https://ec.europa.eu/environment/chemicals/reach/reach_en.htm
- MA Sutton and colleagues 2013. Our Nutrient World: Global Overview of Nutrient Management. GPNM and International Nitrogen Initiative and the Centre for Ecology and Hydrology, Edinburgh; SBTN 2020. Science Based Targets for nature: initial guidance for business, https://sciencebasedtargetsnetwork.org; UN DESA 2020. Sustainable Development – SDGs 3, 6, 12, https://sdgs.un.org/goals.

Taking steps for positive action

Strategic planet-aware action can start now

The focus of the business action targets described above is on action *now*, not deferred until later in the coming decade. In a dynamic and interconnected world, inaction is not the same as standing still. Costs and risks both rise the longer that real change is postponed on the planetary priorities, especially on the pressing global problems of climate change and biodiversity loss.

Fortunately, action can be taken at many levels at once to halt the problematic trends of the past while also setting firm foundations for the system-wide changes that are needed for the future **(Table 5**).

Table 5 – The Action Hierarchy aligns with circular economy principles.
All steps in the hierarchy can be taken together for action to tackle climate change and biodiversity loss.

Action Hierarchy	Strategic target-setting	Climate action	Biodiversity protection
Avoid causing harm	Design out waste and pollution • Refuse overconsumption • Rethink business models • Redesign processes and products	Cut emissions, use less energy	Avoid habitat damage and loss
Mitigate impacts	Keep products and materials in use • Reduce resource flows • Reuse materials	Make efficiency gains through the supply chain	Reduce threats to nature, on site and worldwide
Regenerate	Regenerate natural systems • Recycle materials (including composting, anaerobic digestion)	Strengthen natural carbon sinks, use renewables and low carbon fuels	Rehabilitate landscapes and freshwater and marine ecosystems
Transform	Shift to a restorative economy • Allow recovery from harms • Take responsibility for costs of negative externalities	Offset emissions with verified schemes, invest in carbon recapturing and long-term sequestration	Invest in additional ecosystem restoration, adaptive management

Thinking in terms of the six planetary priorities provides a rationale for developing strategic actions to manage the environmental implications of a transition to circular economy. Keeping all six action targets and their corresponding longer-term global goals in mind helps to ensure that regenerative options really are prioritised.

Efforts can link across geographic scales from the global issues of climate and biodiversity, through the landscape and watershed scales of land and water use, to the factory and farm scale of N and P leakage and chemical pollution. Similarly, changing Earth system conditions (climate and biodiversity) can be linked to their direct drivers (land and water use) and to ecosystem threats (pollution and biogeochemical disruption).

Monitoring progress on all six priorities helps to track the effectiveness of systemically designing out waste and pollution. However, the information requirements and efforts involved in monitoring and tracking progress are substantial. There are still major gaps in knowledge and information about material flows, natural capital, biobased resources, and the effects of large-scale shifts in economic behaviours. Legislation, regulation and technologies also set preconditions to action.

Yet the basic steps for positive action are already very well-known. Taking a planetary perspective on a circular economy can build on several strongly scientifically informed business and policy initiatives already in use internationally (**Table 6**). For example, many businesses already report on climate, water and other components of natural capital. Life cycle analysis and impact assessments allow potential effects of products and business decisions to be evaluated. Science based targets for climate action are well established, showing companies now much and how fast their greenhouse gas emissions need to reduce to avoid contributing to dangerous climate change.

Taking action now provides the necessary foundations for progress to tackle planetary pressures that will otherwise only get worse.

Steps for planet-aware action

Measure the pressures – businesses should compile their inventory of all planetary pressures along the entire value chain, starting with their own operations. Where detailed quantification is not possible, well informed estimates are a good start.

Evaluate the materiality – businesses should assess where along their value chain the main contributions to planetary pressures happen. This may be with suppliers, the facility's own operations, or in the use phase of the products. It can be useful to assess materiality by sector (power, transport, buildings, material, land), in line with climate action evaluations (like We Mean Business Coalition's *Net zero by 2050*).[1]

Prioritise and focus – businesses should routinely reflect on where they have the most influence to shift the problematic trajectories on the planetary priorities, and where their actions will have the most positive impact. This allows for strategic activation of levers for circularity, and effective engagement and networking across the business ecosystem.

Get set to hit the target – tackling planetary problems requires year on year improvements in environmental performance, the ecological quality of the resource system and the circularity of the business ecosystem.

Table 6 – Measurement, monitoring and reporting tools already exist to track progress

Planetary Priority	Global goals by 2050	Business action targets for 2030	Indicative Existing Tools[24]
Climate change	Carbon neutrality	Cut CO_2 emissions at least 8% per year from 2020 levels	CDP / Science Based Targets GHG Protocol Carbon footprint, Ecological footprint Life cycle analysis
Biodiversity loss	30% of world's ecosystems protected, safeguarding human rights	Ensure no net loss of land and marine habitats, increasing conservation and restoration	CDP / Science Based Targets (forest) Species Threat Abatement and Recovery metric (STAR) SEEA Ecosystem accounting[25]
Land use	20% of world's area restored to ecologically resilient conditions[26]	Halt deforestation, recover degraded croplands	Land footprint Ecological footprint SEEA Ecosystem accounting
Water use	Watershed withdrawals below 40% of renewable supplies	Reduce freshwater abstraction and consumptive use by 30%	CDP / Science Based Targets (water) Blue and green water footprints Context-based targets
Chemical pollution	No harmful environmental releases, allowing for circular and restorative production systems	Prevent release of harmful chemicals. Halve pesticide use. Reduce all waste generation.	Chemical footprint The New Plastics Economy global commitment[27]
N & P flows	50% improvement in long-term full-chain nutrient use efficiency	Comply with local air and water quality regulations and policy targets for N & P	Nitrogen and phosphorus footprints Gray water footprint

[24] Methods and measurement tools are outlined in T Häyhä and colleagues 2016. From Planetary Boundaries to national fair shares of the global safe operating space — How can the scales be bridged? *Global Environmental Change* 40: 60-72 and T Häyhä and colleagues 2018. *Operationalizing the concept of a safe operating space at the EU level – first steps and explorations.* SRC Technical Report for the European Environment Agency, with SEI and PBL Netherlands Environmental Assessment Agency.

[25] UN System of Environmental Economic Accounting, https://seea.un.org

[26] The Bonn Challenge mobilizes global efforts for landscape restoration www.bonnchallenge.org

[27] www.newplasticseconomy.org/projects/global-commitment

Business and science dialogues support bolder ambition

In times of rapid global changes, brands need to ***step up their own efforts*** to help meet internationally agreed policy goals, ***work together*** for the system-wide shift to circular economy, and also ***keep informed of scientific developments.***

In a dynamic and interconnected world, industry targets and efforts need to go well beyond today's efforts at climate action. Bolder ambition is needed to support positive gains on the other planetary priorities while driving the shift to a regenerative circular economy. Existing science-based targets for climate already deal with some land and water impacts, but their methods are focused rather narrowly on climate policy and carbon emissions. Additional biosphere targets are needed to ensure that ecosystems can sustain life, contribute ecosystem services, and provide resilience.

The international Science Based Targets Network[28] recognizes the important links between the planetary priorities and their role in shaping how the Earth system functions. The SBT Network brings business, science and NGOs together. It is working to translate the latest scientific evidence of global changes into measurable, policy-relevant targets and actionable guidance for businesses. Stronger methodologies are currently being developed for contextual sustainability metrics for water, to help protect the vital environmental water flows that sustain resilient landscapes[29]. New science-based targets for nature[30] are also currently being developed to deal with the other planetary priorities. And alongside these new science-based targets, international systems for transparency, scientific quality-checks and mutual accountability are being developed.

The intention of these current conversations between business and science is to ensure that companies can shift to doing what it takes to stay within the limits of Earth's biophysical systems. By focusing on regenerative and restorative systems and expanding their scope to include planetary priorities, businesses in the fashion and textiles industry have great potential to be part of this movement for change.

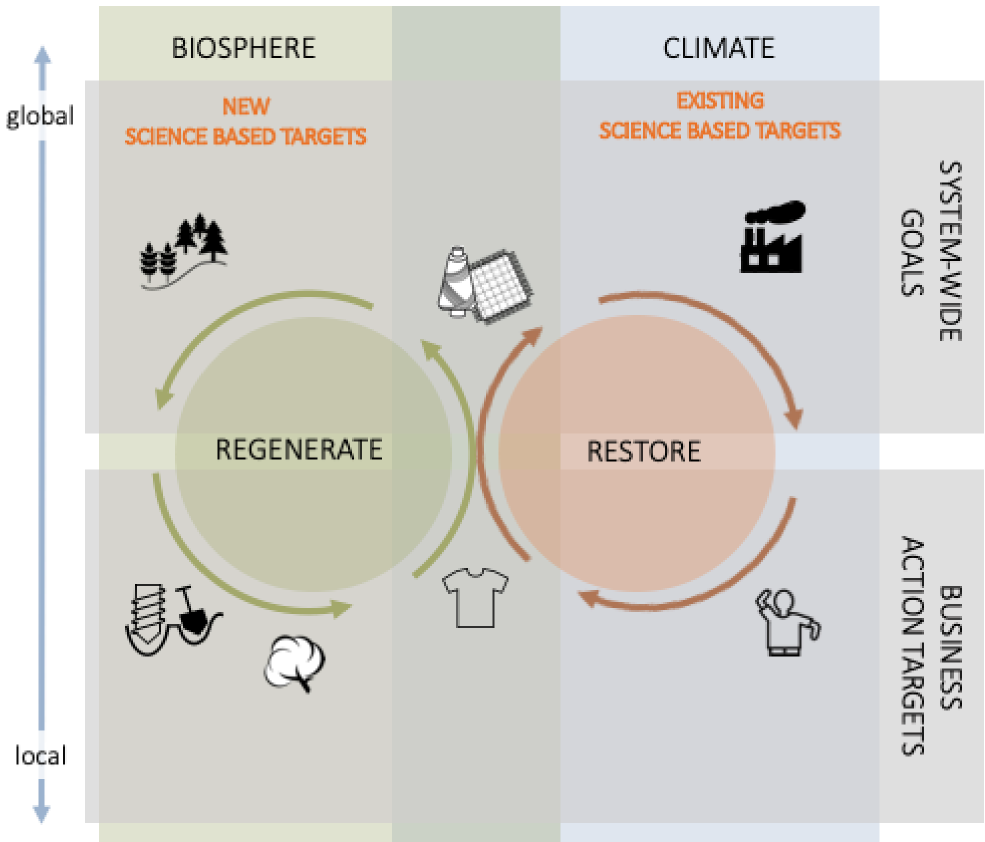


Figure 7 – Steering the shift to circular economy with business action targets and system-wide goals for climate and the biosphere

[28] The Science Based Targets Network connects the SBTi with other organisations and intern scientific networks to define the scientific basis for targets for concerted business action on other environmental pressures: https://sciencebasedtargetsnetwork.org

[29] e.g., CEO Water Mandate 2017. *Exploring the case for corporate context-based water targets*. CDP, WRI, TNC, WWF and Pacific Institute

[30] SBTN 2020. *Science Based Targets for Nature: initial guidance for business*. Science Based Targets Network / Global Commons Alliance https://sciencebasedtargetsnetwork.org/wp-content/uploads/2020/09/SBTN-initial-guidance-for-business.pdf

Appendices

A. Our social-ecological systems approach: central concepts and methods

In today's globalised world, societies, economies and the living environment are connected in unprecedented ways. There are now virtually no ecosystems that are not shaped by people and there are no people without the need for life-supporting ecosystems and the services they provide[31].

The scientific starting point for this report is that these complex connections between people and the natural world can be understood in terms of ***social-ecological systems***[32]. Social-ecological systems are made up of many human and non-human 'components' that interact in diverse ways. These components and their interactions respond to changes in their environment – and their environment changes as a result. This report takes a global-scale, long-term perspective on social-ecological systems, with particular attention to changes affecting the world's ecosystems that maintain climate stability and provide water, food, fibers and many other beneficial functions.

Resilience is the capacity of a system to deal with change and continue to develop[33].

- Ecological resilience is a measure of how much disturbance an ecosystem can withstand without shifting into a different state. Resilient ecosystems have the capacity to regenerate themselves if damaged.

- Social resilience is the ability of human communities to withstand and recover from stresses, such as environmental change and social, economic or political upheaval. Resilience in societies and their life-supporting ecosystems is crucial in maintaining options for future development.

The adaptive cycle is a simple representation of a typical behaviour of such complex dynamic systems. **Figure** represents the system going through phases of creation, consolidation and reconfiguration. In the creation phase, components self-organize to form their system, which then grows rapidly through exploitation of available resources. Over time, some components in the mature consolidated system can become dominant, and difficulties may arise in accessing resources. These kinds of internal factors can change the system conditions so much that the system reaches a crisis point and the established pattern needs to change. Alternatively, an external factor can also trigger rapid change. Managed well, this phase of reconfiguration and re-organisation can be a renewal. But sometimes, it can be a systemic collapse.

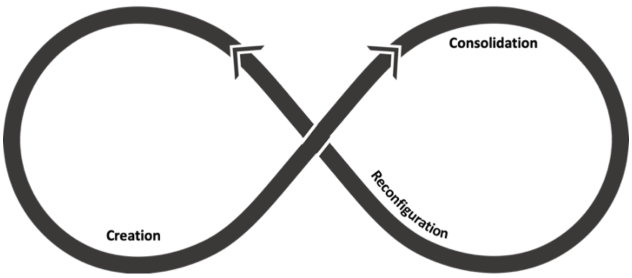


Figure 13 – The adaptive cycle represents a system's processes of self-organisation and evolution

It is useful to keep in mind that adaptive cycles often link social and ecological aspects of the system. This helps to explain how socio-economic challenges often play out as environmental pressures and vice versa; and how the biological and technical loops of circular economy interact and constrain each other.

It is also important to think of adaptive cycles as spanning across multiple scales of time, space and social organisation. Social challenges and environmental pressures cross scales, resulting in complex patterns of risk and opportunity. Rather than seeing local, regional and global change as a hierarchy of separate processes, adaptive cycles involve a 'panarchy' of many interactions playing out at the same time[34]. Seeing more of these interactions helps explain how adaptive systems can

[31] IPBES Global Assessment Report 2019

[32] F Berkes and colleagues 2002

[33] C Folke and colleagues 2010. Resilience Thinking: Integrating resilience, adaptability and transformability. *Ecol Soc.* 15(4): 20

[34] LH Gunderson, CS Holling 2002. *Panarchy: Understanding transformations in human and natural systems*. Island Press

generate novel reconfigurations and exploit new opportunities.

The fashion and textiles system is a social-ecological system. Its 'components' include the textile fibres and other material inputs that become garments, and also the diverse social, cultural and economic factors that shape people's fashion choices and practices. In other words, the fashion and textiles system is made up of more than business decision-making about turning resource flows into goods for fashion users. It includes global goal-setting, national policy-making and foresighted actions of business networks. It is shaped by enabling conditions of technologies and emerging constraints from environmental pressures. Its options for action involve a much bigger 'business ecosystem' than just the fashion and textiles industry itself. Steering the behaviour of the global industry towards long-term resilience depends on better ways to navigate the complex interplay of all these components.

A core challenge for diagnosing the sustainability of social-ecological systems and for helping to navigate systemic transformations – like the shift from a linear economy to circular economy – is how to identify and analyse the relationships that matter in the system. We use a framework developed by Economics Nobel laureate Elinor Ostrom (**Figure 14**) that helps trace cross-scale interactions for better analysis of sustainable natural resource use, decision making and self-organised action in social-ecological systems[35]:

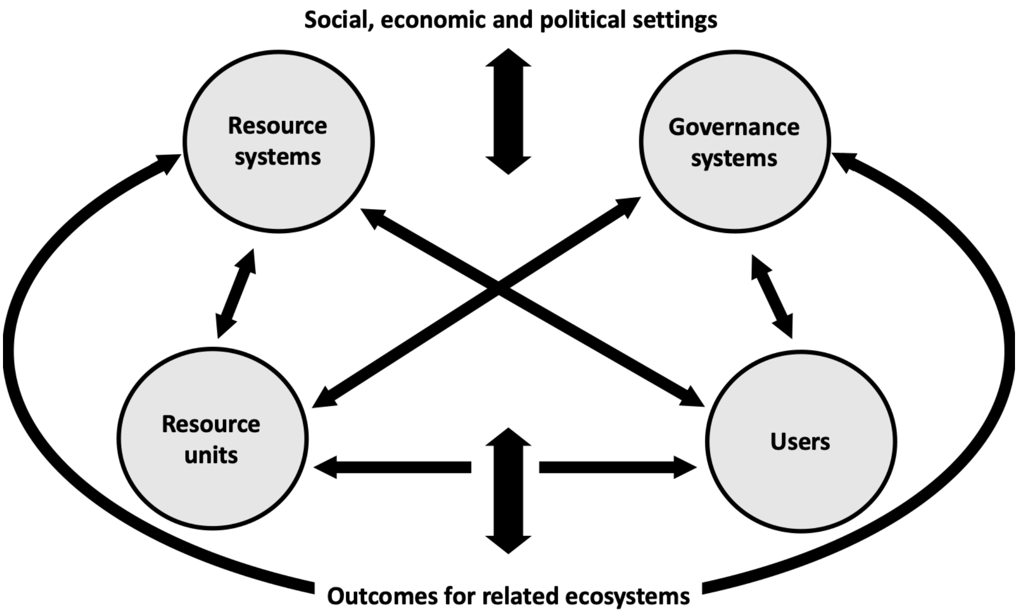


Figure 14 – Ostrom's general framework for analysing sustainability of social-ecological systems

[35] E Ostrom 1990. Governing the commons: the evolution of institutions for collective action. Cambridge University Press

B. How are the Planetary Boundaries measured – and how do these scientific measures relate to business?

For a discussion of the translation of the planetary boundaries framework to national decision levels, see T Häyhä and colleagues 2016. From Planetary Boundaries to national fair shares of the global safe operating space — How can the scales be bridged? Global Environmental Change 40: 60-72

For discussion of the link between planetary boundaries and LCA, see A Bjørn and colleagues 2015. Strengthening the link between Life Cycle Assessment and indicators for absolute sustainability to support development within Planetary Boundaries, Environmental Science & Technology 49(11): 6370–6371

For discussion of context-specific translations of the framework, see M Vargas Gonzalez 2018. Integrating the concept of Planetary Boundaries into decision making processes, in: E. Benetto and colleagues (eds.), Designing Sustainable Technologies, Products and Policies, Springer, p 407-412.

Climate Change

The indicator of climate change in the planetary boundaries framework is the concentration of CO_2 in the atmosphere. This one indicator is very robust as a marker of human change on the climate system, because CO_2 is the most abundant long-lived greenhouse gas. Its main human-caused source is fossil fuel use. Some of the emitted CO_2 is taken up by land vegetation and marine plankton and then enters the living 'cycles' of the Earth system. The rest accumulates in the oceans, causing ocean acidification, and in the atmosphere, causing global warming.

At the operational level of business decision-making, most companies focus on greenhouse gas emissions, which contribute to rising atmospheric concentrations. From the long-term perspective of planetary boundaries, the priority action is to cut CO_2 emissions but to minimize and slow the rate of global warming overall, cutting emissions of other greenhouse gases is also important. These include methane and nitrous oxide from agricultural sources, and industrially produced climate-active substances such as chlorofluorocarbons (CFCs) and their replacements.

Ocean Acidification

Although CO_2 is the principal driver of ocean acidification, the indicator used in the planetary boundaries framework is the aragonite saturation, a specialised measure of the geochemical effect of acidification in the oceans. As ocean acidification intensifies, the effects on marine life are complex and poorly predictable but include changes in calcification (shell and coral formation), photosynthesis, metabolism and chemical signalling affecting organism behaviour and structures of ecosystems.

At the level of business decision-making, aragonite saturation is not a readily operational measure. For this reason, in this report we combine climate change and ocean acidification into one planetary pressure. Human-caused CO_2 emissions are the shared main driver, so business action for climate change mitigation will generally also mitigate ocean acidification.

Biosphere integrity

The global rate of species extinctions is the planetary boundary indicator for the loss of genetic biodiversity and the maintenance of the integrity of the biosphere - the entirety of life on Earth and the complex web of its relationships. The diversity and abundance of living organisms underpins long-term Earth system functioning by regulating natural material and energy flows and by providing resilience to both abrupt and gradual change. The extinctions metric for this planetary boundary is now complemented with a more readily operational measure of biodiversity intactness. The Biodiversity Intactness Index which can be monitored scientifically at more local scales and on shorter timescales than extinction statistics. It has been mapped globally using a combination of conservation monitoring data and model-based biome analysis.

At the moment, business decision-making generally takes a relatively small-scale, short-term and retrospective view on biodiversity losses, with a focus on species and habitat conservation. Unless this is complemented with measures to regenerate ecosystems and restore their functioning across scales from local to planetary, the progressive global decline of biodiversity will continue.

Land system change

The planetary boundary was initially measured in terms of the global land area used for crop production, but has since been revised to the amount of forest cover. Both indicators reflect the way that land cover plays a key role in the Earth system. Shifts from forest cover to agricultural uses cause major changes in heat, carbon and water flows, with impacts on climate and the hydrological cycle. Land use change is also a major threat to biodiversity, biosphere integrity and ecosystem functions.

The area-based planetary boundaries metrics for land use can be readily applied in business decision-making. It may be useful to assess impacts of production and trade systems on both cropland and forest cover. Overall impacts will depend on which land cover type is most affected by decisions about raw materials sourcing.

Freshwater use

This planetary boundary is an estimate of the total global volume of 'blue' water consumption (that is, the use of water from rivers, lakes, reservoirs and renewable groundwater sources) that would alter Holocene functions of the water cycle. The volume quantification – in cubic kilometers – is difficult to determine precisely but at the global level, freshwater use is likely still within the boundary of Holocene-like variability. However, the pressure on water resources is increasing fast, mainly because of growing demands for biomass. There are large seasonal and geographic differences in water availability and demand (including the need to maintain environmental water flows), and the societal impacts of water scarcity also vary greatly. For all these reasons, the planetary boundary should not be seen as a global budget to be shared. Instead it should be seen as a proxy measure for a much more complex pattern of ecological and physical effects of human use of water resources.

Businesses need to take these context-specific factors into account for a sensible translation of the freshwater planetary boundary to operational levels.

Biogeochemical flows

The planetary boundary indicators are measures of the global environmental flows of reactive forms of nitrogen (N) and phosphorus (P), two essential nutrient elements that play a vital role in supporting life. For both N and P, the sparsity of global data and the complexity of nutrient cycling through living nature, land, water and (for N) the atmosphere together make it is difficult to define a precise Holocene baseline, although both cycles have been greatly altered by human activities. Land and ocean ecosystems have already changed radically in response to past flows, and social systems are partly dependent on these human-modified conditions. The planetary boundary indicators have therefore been defined in terms of the global flows where measurable human influence is greatest: the amount of industrial and agricultural N fixation into reactive and bioavailable forms, and the flow into the oceans of P eroded from agricultural soils.

Neither of the N and P metrics is readily operationalizable in business decision-making. And the flow-based metrics themselves are not translatable into planetary 'budgets'. In this report we focus on the N and P in freshwater and wastewater, and on N-containing air pollutants and climate-active gases, because these are the main ways that global trade and industry alter the biogeochemical flows in the Earth system.

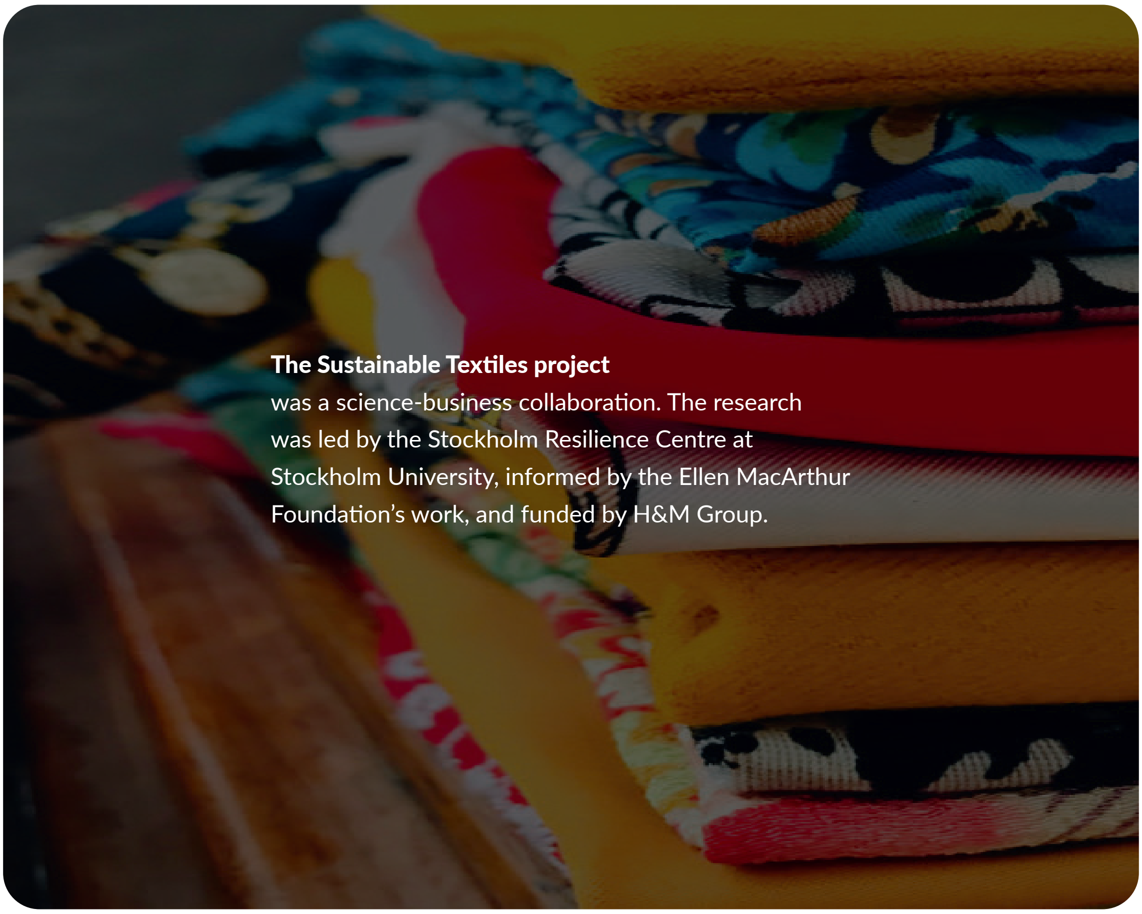
Chemical pollution

- **Novel entities** – There is no single global quantification for this planetary boundary. The planetary boundaries framework highlights the fact that new synthetic substances, new forms of existing substances and modified life-forms can cause unwanted Earth system effects, and all such entities can be seen a departure from the Holocene baseline. Novel pollutants can disrupt large-scale ecosystem functioning (the banned insecticide DDT is a well-known example) and can also affect non-living processes such as the greenhouse effect, ozone chemistry and atmospheric particle formation. The biggest concern is that these systemic changes can be irreversible, calling for strongly preventive and precautionary approaches.

- **Stratospheric ozone depletion** – The planetary boundary indicator is expressed in Dobson Units of ozone concentration, a measure obtained using a combination of ground-level and upper atmosphere instruments and satellite observations. The depletion of the ozone layer started in the 20th century, when industrially produced chlorofluorocarbons (CFCs) accumulated in the atmosphere and set off chain reactions that destroy ozone. As a wholly new family of substances, it is easy for atmospheric scientists to see the global 20th century signal against the Holocene baseline concentration. As for CO_2, the global concentration-based metric is not used in business decision-making. At the moment, ozone depleting substances are being phased out at source in compliance with the Montreal Protocol, so very few companies have a need to routinely measure or report ozone-depletor emissions directly.

- **Atmospheric aerosol loading** – The top-of-atmosphere optical depth is the metric used in the planetary boundaries framework. It relies on satellite observations that measure the global distribution of aerosol particles in the atmosphere in ways that can be combined with models of climate, land use, marine biogeochemistry and other Earth system processes where atmospheric particulate matter plays a vital role. For business decision-making, ground-based air quality measurements capture some components of atmospheric particulate loading. These can be very precise measurements compared with the global satellite data, but they have a much smaller spatial reach and do not give much insight into the ways that aerosol changes affect the longer term, larger scale processes that matter for climate and the biosphere.

For day-to-day business decision-making, then, none of these three pollution-related planetary boundaries have readily operational measures. In this report we have therefore combined the three human-caused pollution issues into one planetary priority that businesses actually can act on now: tackling the pressures caused by large-scale systemic chemical pollution.



The Sustainable Textiles project
was a science-business collaboration. The research was led by the Stockholm Resilience Centre at Stockholm University, informed by the Ellen MacArthur Foundation's work, and funded by H&M Group.

www.stockholmresilience.su.se

Stockholm Resilience Centre
Sustainability Science for Biosphere Stewardship

Stockholm University