



Linking planetary boundaries to business

Part of Kering's series on Planetary
Boundaries for Business

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Executive summary

The majority of companies today are seeking to reduce their environmental impacts, increase resource efficiency and mitigate risks from climate change. However, decisions to take action are being made without any real knowledge of what is actually sustainable in a finite global system.

Further, it is unclear to what extent these company's actions, especially when compounded with those of others in their sector and across sectors, will be contributing to natural resource limitations at a global scale. To address these important challenges, the concept of Planetary Boundaries (*PBs*) provides an appropriate context.

The nine *PBs*^a, by their very nature, are global and overall they provide boundaries for the planet to maintain a stable state necessary to support contemporary society. The *PB* framework can also offer a viable approach for the business community. The adoption of the *PB* framework would help companies understand the consequences of their environmental impacts at a global level and provide them with a critical new perspective. This, in turn, would give companies the ability to move beyond strictly focusing on solutions to their "single issues" to more meaningful decisions and responses to help us restore a well-functioning planet. More profoundly, the adoption of the *PB* framework could trigger a deep change in our thinking about the role of our businesses – and ourselves – in this rapidly changing world.

As such, there is growing interest in applying the *PBs* within the business context. A key component to this development will be how to translate the *PBs* into science-based corporate targets since this will enable companies to better prioritise and be more focused in their actions and sustainability efforts. Already, some leading organisations and companies have embarked on exploring application of the *PBs*. As an example, work has been done to develop impact metrics on biodiversity^b that can connect back to the *PBs*. However, we are just at the beginning of understanding how to link different metrics and approaches in a way that appropriately translates science-based targets to planetary limits within a business context.

As the first White Paper in Kering's series on Planetary Boundaries for Business, which Kering is developing and sponsoring, this paper underlines the value of the *PB* framework and provides an overview, as well as key insights, into how the *PBs* can help inform business decision-making. In short, the aim of the paper is to launch an ongoing discussion around using the *PB* framework in the context of corporate sustainability by:

- Introducing the value of the *PB* framework along with its challenges and limitations
- Exploring how the *PBs* could be applied in a corporate context
- Proposing innovative approaches based on the *PB* concept
- Identifying the next steps to integrate the business community into the *PB* framework development

Subsequent White Papers in the series will explore further perspectives on using the Planetary Boundary framework, as well as science-based targets and natural capital accounting and the importance of the connections between these concepts for business to tap into improved information and metrics. Ultimately, the aim of the series is to support the understanding of the *PB* framework's benefits for the business community so that companies are better prepared to design appropriate actions that can deliver positive outcomes and enable them to stay within their business 'boundaries'.

A key recommendation from this initial White Paper is focused on the importance for companies to consider, through further research, the opportunities and limitations of 'downscaling' and 'upscaling' the *PB* framework to better inform their sustainability decisions. The challenge of developing sustainability solutions that work at different scales (global vs local) and the risks of potential associated trade-offs also needs to be carefully explored from both scientific and business perspectives. For example, business impacts can be understood on a global scale for certain *PBs*, but also have to be taken into context at the local or on-the-ground level for other *PBs*. Additionally, at local or regional levels, guidelines or regulations designed explicitly for those levels may be more stringent than those inferred from the *PBs*, which are designed to operate at the global level. Through this Paper's exploratory work, it has also become clear that reducing the *PBs* to local or regional scales ('downscaling') may not be scientifically robust. Alternatively, it may be more appropriate to 'upscale' the impact of a company on a given location or ecosystem to the *PB* level. This approach would enable a company to identify how their actions and impacts, if scaled to a global level, can contribute to maintaining the Earth System processes within the *PBs* or not. In particular, using 'upscaling' to assess impact on the core *PBs* of climate change and biosphere integrity can provide a new context for companies. Initial analysis suggests that an 'upscaling' approach highlights the need for regenerative activities as opposed to the eco-efficiency gains that a 'downscaling' approach seems to drive. Simply put, this would encourage companies to shift towards activities that focus on doing "more good" (by considering 'upscaling') rather than incremental changes or doing "less bad" (by focusing on 'downscaling').

There are obvious challenges and work still to be done in this field but it is clear that linking the *PBs* to business is both an opportunity and a responsibility to create a new, more robust agenda for managing and mitigating our global environmental issues. It is only with this type of approach that we will be able to maintain the Earth System within a safe operating space for humanity and for a more sustainable future.

^a Climate change, biosphere integrity, land-system change, freshwater use, biogeochemical flows, ocean acidification, atmospheric aerosol loading, stratospheric ozone depletion, and novel entities

^b www.cisl.cam.ac.uk/publications/working-papers-folder/healthy-ecosystem-metric-framework



A word from the scientific community

Scientifically, the Planetary Boundaries framework is the natural next step building on remarkable advancements in Earth System science over the past 40 years. We now have convincing evidence and new insights that we are no longer a small world on a big planet, we are a big world on a small planet.

We have entered a new geological Epoch, the Anthropocene. This is a high risk and a grand challenge as we now know that our modern world depends on the relative stability of the climate system and the biosphere we have experienced in the Holocene, since the last Ice Age, some 12,000 years ago. We also know that tipping points in the Earth System are real and can lead to self-reinforcing processes pushing our Planet into undesired territory.

It is based on these insights that the obvious question arises, to remain in a manageable Holocene-like state of the planet, what are the processes that regulate the state of the planet? And can we scientifically, for each of these processes, quantify a boundary, beyond which we risk moving into dangerous territory, while within them we have a safe operating space for humanity on Earth. The Planetary Boundaries framework was born. Primarily as a challenge for science, and increasingly adopted by policy, civil society and the business community.

For business, we in the scientific community see a very important trend. Acting on the rising evidence of global environmental risks and resource scarcity, there is a clear trend where sustainability is shifting

from ethically driven environmental protection within the domain of corporate social responsibility (still justifiable and important), to becoming an integral part of the business model. Businesses increasingly call for science-based targets to guide investments, innovation and performance indicators along the value chain.

I increasingly receive the quest to science from business leaders that “what we really need are the 2°C equivalents for the planet”, i.e., what are the science-based targets for all planetary boundaries, and not only climate, if we are truly going to transition business and world development to a sustainable, safe and just future? I hope that the Planetary Boundaries framework and the rapidly advancing science on global sustainability can assist in providing Business with the science it needs for responsible business prosperity in the Anthropocene.

Johan Rockström

Executive Director, Stockholm Resilience Centre

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Businesses increasingly call for science-based targets to guide investments, innovation and performance indicators along the value chain.

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Introduction

The Planetary Boundaries framework is based on nine interacting processes that, taken together, determine the condition or state of the Earth System. The boundaries define a safe operating space for humanity that should not be transgressed if we want to maintain stable conditions at the Earth System level.

The Planetary Boundaries (*PB*) framework was first introduced in 2009¹ as a science-based guidance system for human development on Earth. It tracks the increasing impacts human activities are having on our planetary life support system. The fundamental principle on which the *PB* framework rests is that our actions are undermining the relatively stable conditions of the past 12,000 years. This unique period of stability of the climate, and of the Earth System as a whole, known as the Holocene epoch, has allowed humanity to develop agriculture, settlements and the complex societies we have today.

The *PB* framework was originally designed to inform global scale decisions. It has provided the global environmental input to the United Nations's seventeen Sustainable Development Goals² (SDGs) and has informed EU policy, as well as national policies and targets in Sweden and Switzerland. The University of Cambridge Institute for Sustainability Leadership (CISL) has also used the *PB* framework to inform corporate actions through its 'Rewiring the Economy'³ approach. This approach proposes three specific environmental outcomes that can be achieved through innovative thinking and targeted tasks: (i) to preserve the stocks of natural resources through efficient and circular use; (ii) to maintain ecologically sound landscapes and seas for nature and people; (iii) to limit GHG levels to stabilise global temperature rise under 2°C.

1.1 The challenge

It is widely acknowledged that the world's natural resources and ecosystem services are being degraded and lost at an alarming rate. In fact, resource scarcity is becoming one of the fundamental drivers for many corporate sustainability initiatives. As such, more and more companies are adopting a focused sustainability agenda in order to remain resilient and successful into the future. However, despite the evident need to halt biodiversity loss and ecosystem decline, mitigate climate change and improve environmental conditions more broadly, the business case and incentives to do so are currently weak. The challenge is that environmental issues are still viewed as "externalities" in the current economic paradigm. Hence, nature continues to be degraded and under-valued rather than being seen as the essential natural capital⁶ that requires stewardship and investment for our society's future survival.

There has certainly been some important progress over the last several years however. Now there are many resources and initiatives that provide advice and guidance to companies on specific actions, targets or metrics for more sustainable business decisions⁴⁻⁷. Significantly though these do not articulate sustainability in the context of limited resources and natural capital, but rather equate "less impact" with being sustainable. Additionally, they are often focused on single issues, albeit large ones, and are almost always focused on ecosystems and the environment at local or regional levels. They do not take into consideration the context of the Earth System as a whole. A new and more sophisticated awareness is needed to understand what business actions are indeed sustainable. In this way we will be able to prioritise the approaches that can offer multi-benefit solutions that address several challenges, and in particular, those associated with the destabilisation of the Earth System as a whole. It is the *PB* framework that can provide us with the context for guiding action to improve not only ecosystems and biodiversity (our natural capital) at local and regional scale, but also the planetary systems that govern the stability of the Earth System.

Using the *PB* framework to inform corporate sustainability decisions, especially in supply chains, will enable business to understand the consequences of their impacts on a macro level and will help them focus on specific actions to address these.

The aim of this first White Paper is to launch an ongoing discussion around using the *PB* framework in the context of corporate sustainability by:

- Introducing the value of the *PB* framework along with its challenges and limitations
- Exploring how the *PBs* could be applied in a corporate context
- Proposing innovative approaches based on the *PB* concept
- Identifying the next steps to integrate the business community into the *PB* framework development

⁶ Natural capital is another term for the stock of renewable and non-renewable resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people

The planetary boundaries

2.1 The conceptual framework

The PB conceptual framework is a science-based approach to understanding humanity's impact on the Earth at the planetary scale. It is based on the concept of the Earth as a single complex system with interrelated processes that maintain the stability of the system.

Since humans have existed, the Earth System has oscillated regularly between two states, a cold glacial state and a warmer interglacial state. The current warm state, the Holocene, has existed for nearly 12,000 years. The Holocene is the only state of the Earth System during which humans have been able to develop agriculture, settlements, cities, and, ultimately, the complex societies that we enjoy today. Based on the changes to the Earth System, experts say that we are no longer in the Holocene but have moved into a new epoch, which is already characterised by increasing instability. They define this as the Anthropocene.

The PB framework provides a guidance system for maintaining a state of the Earth System that resembles the Holocene. The framework is built around nine fundamental global processes that, together, define the state of the Earth System (Figure 1).

The actual boundaries articulated within the PB framework define the “safe operating space” for humanity. These are, in turn, based on nine global processes: climate change, biosphere integrity, land-system change, freshwater use, biogeochemical flows, ocean acidification, atmospheric aerosol loading, stratospheric ozone depletion, and novel entities. The state of each of these processes is defined by a “control variable”, for example carbon dioxide concentration for climate change. The boundaries themselves are defined by a position (measurement) of the control variables that, if crossed, could generate unacceptable change to the functioning of the Earth System.

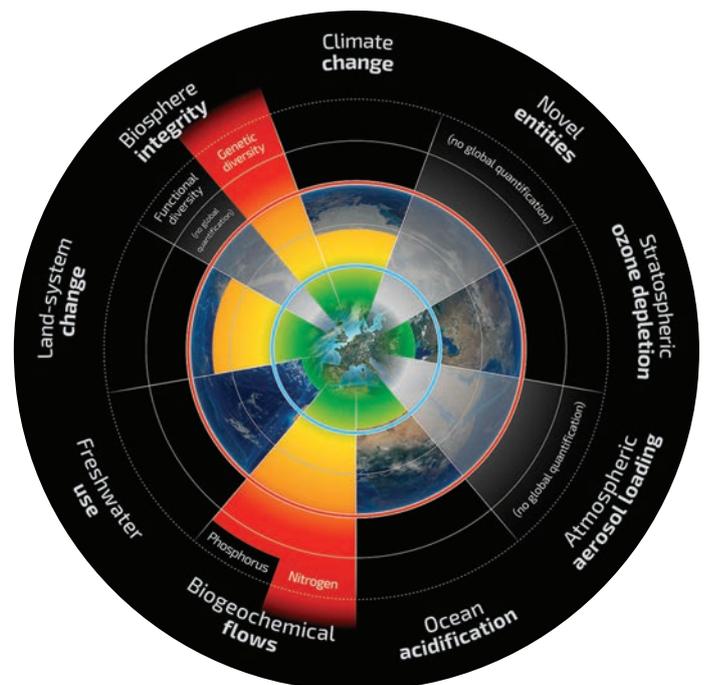
The “zone of uncertainty” associated with each of the boundaries (Figure 1) highlights where there are gaps in scientific knowledge and uncertainties in the functioning of the Earth System. However, even if the extent of change is currently unknown, it is clear that when the variables are in this zone there is increasing risk of unacceptable environmental change. The “zone of high risk” represents a much higher probability of dramatic change to the functioning of the Earth System that could potentially be devastating for human societies.

More details on the core definitions and terms can be found in the Appendix.

Figure 1. The planetary boundaries framework showing the nine boundary processes. The position of the control variable(s) for each of the PBs is shown with respect to the safe operating space, zone of uncertainty and zone of high risk^d

- Beyond zone of uncertainty (high risk)
- In zone of uncertainty (increasing risk)
- Below boundary (safe)
- Boundary not yet quantified

^dAdapted from Steffen et al. 2015⁵



2.2 Transgressing the planetary boundaries

Four of the nine Planetary Boundaries have now been transgressed as a result of human activity⁸. These are: climate change, loss of biosphere integrity, land-system change, and altered biogeochemical flows (phosphorous and nitrogen).

Transgressing any individual boundary increases the risk that the Earth System will be driven into conditions that will lead to the deterioration of human wellbeing. Transgressing several boundaries obviously heightens this risk. However, not all boundaries are equal in the sense that driving certain processes beyond their boundaries can have more significant impacts than others. These boundaries are known as “core boundaries” and include *climate change* and *biosphere integrity*. They are the only two *PBs* that, on their own, when transgressed, will drive a significant change in the state of the Earth System.

The fact that four of the *PBs*, including the two core boundaries, have already been transgressed and are now in the “*zone of uncertainty*” and the “*zone of high risk*” is alarming for us all. It also means that there are immediate implications for how companies consider their impacts on the planet. Simply put, there should not be any activities that drive impact on these boundary processes (i.e. no further pressure on their control variables). This has already been recognised by the global community with regards to mitigating climate change, where there is agreement that atmospheric CO₂ concentration must be limited. However, there is a great deal less awareness, and also agreement, around mitigating impact on the biosphere variables.

The core boundaries also help guide prioritisation of action; mitigating the transgression of the two core boundaries should overrule other boundaries.

2.3 Interactions between the planetary boundaries

Although the *PBs* are defined and presented as independent processes, they are in fact highly interdependent.

Changes in one boundary process can influence the other boundaries. This is particularly true for the core *PBs* (*climate change* and *biosphere integrity*) that are significantly influenced by changes in the other seven boundaries. For example, *biosphere integrity* is affected by increasing *ocean acidification*, loss of major forest biomes (*land-system change*), eutrophication from nitrogen and phosphorus pollution (*biochemical flows*) and overuse of *freshwater* resources.

Non-core boundaries are also interconnected. Taking the *land-system change PB* as an example, we know that it is based on the role of the three major forest biomes (boreal, temperate, tropical) in modulating Earth’s climate through two key geophysical processes: i) fluxes of water vapour between the land surface and the atmosphere and ii) reflection or absorption of sunlight. However, changing the amount of forest cover also releases or sequesters CO₂ with consequences for the *climate change PB*. In addition, further degradation of forest biomes will increase the transgression of the *biosphere integrity PB*.

In this example of *land-system change* and its interactions with the core boundaries, it is clear that restrictive targets are needed on any further degradation or loss of forest. In fact, due to the interconnected nature of the core *PBs* *climate change* and *biosphere integrity* with *land-system change* it could be argued that a target should be set for zero deforestation in all of the major forest biomes around the world and additional significant reforestation action should be supported.

This demonstrates the need to consider more than one *PB* to inform actions; were the *PB* for *land-system change* alone considered it may appear that limited action is needed on the Amazon rainforest and the eastern American temperate forests, which remain within the safe operating space albeit only just (the Amazon is approximately 90 percent intact which is a little over the estimated limit of 85 percent to remain in the safe operating space). This would not be a correct conclusion based on the interconnected nature of the *PBs*.

Considering the interactions between the *PBs* also points to the need to go beyond reducing negative impact to implementing actions that restore forests, sequester CO₂, etc. In other words, a regenerative, rather than an exploitative, approach is required for us to return to within the core *PBs*, thereby reducing risk and enhancing stability.

2.4 The planetary boundaries – key takeaways

- Transgression of the core boundaries at the same time drives more rapid deterioration and destabilisation of the Earth System
- *PBs* are interconnected; understanding the interactions between the *PBs* is important, particularly the core boundaries, *climate change* and *biosphere integrity*
- The two core *PBs* interact with all other seven *PBs* and can thus act as an overall integrator as well as a limiting factor for other *PBs*
- Action should be prioritised with an initial focus on the core boundaries
- Regenerative approaches offer solutions across the *PBs*

Business implications

The science is clear: if the planet is destabilised, there is a significant probability that our complex society will unravel. The implications for business are large if efforts to avoid this are not put in place; as resource constraints heighten and inequality escalates, markets will likely rapidly shift and consumer behaviours could change markedly. A continuation of the destabilisation of the Earth System could create chaos for all sectors with the escalating risk of a collapse of the globalised economic system overall as a real possibility.

It can be tempting to think of the consequences of transgressing the *PBs* as an extreme, long-term trajectory that does not fit with existing short-term company visions and timelines. However, this would be a mistake for three reasons:

1. We are already experiencing the effects of transgressing four of the *PBs* and as we move out of the “safe space” on the remaining five boundaries there will be additional short-term impacts.
2. It is far easier to create opportunities and secure resilience and stability now before all the *PBs* have been transgressed with irreversible and potentially catastrophic consequences.
3. There is evidence that the rate at which global processes are changing and moving beyond the *PBs* is not linear and may escalate more rapidly than they have in the past.

Companies can help remove and mitigate these risks by taking steps in the right direction now.

3.1 The risks for business

Clearly, the transgression of the *PBs* has serious implications for society and humanity. However, there are also some specific risks for business. These can include dramatic supply chain disruption, shifting markets, new and extensive regulatory compliance, increased cost and increased scarcity of raw materials. While these risks have often been recognised in the context of impacts of climate change, it is important to understand that these risks are also driven by other impacts on global processes.

The *PB* framework provides a perspective on the interconnected drivers of strategic risks; it provides critical information for companies to focus on mitigating actions around key variables. It also provides the broad and appropriate construct in which to design actions and approaches that can deliver multiple benefits across a number of processes rather than the approach of focusing on single drivers and processes.

3.2 The opportunities for business

The first important step is for companies to become aware of the impacts of their actions on the Earth System and the interconnectedness of the drivers that maintain or undermine

the stability of the system. Translating these challenges to the level of the business sector and/or to an individual company is much more difficult. However, it presents a significant opportunity for innovative thinking and action by the private sector in their own efforts as individual companies and also in collaboration with academics, sustainable development practitioners and governments.

Beyond building awareness there is the obvious need for action. To make the *PBs* more accessible for defining the type of actions companies need to make, there is a natural desire to operationalise them at a scale more appropriate and relevant for business decision-making and at the local, national, and regional levels. As an example, the Science Based Target initiative (SBTi), a collaboration between CDP, the United Nations Global Compact (UNGC), World Resources Institute (WRI), and the World Wide Fund for Nature (WWF) defines and promotes best practice in science-based target setting with the aim that by 2020 science-based target setting will become standard business practice and corporations will play a major role in driving down global greenhouse gas emissions. However, this is challenging due to the global nature of the *PB* framework which is based on the functioning of the Earth System as a whole. More work and thinking is needed to identify which actions and approaches can be used at particular scales in order to support and drive the business community towards avoiding or reversing transgression of *PBs*. A number of these operational areas will be covered within this White Paper on Planetary Boundaries for Business that Kering is developing and sponsoring. Meanwhile, there are still useful approaches and insights that can be generated by thinking creatively across scales and within the *PB* framework. It is also important to note that the *PBs* and climate targets should not be treated separately from the extensive work and thinking around Natural Capital Accounting.

3.3 Business implications – key takeaways

- Transgressing the *PBs* will create business disruptions, including cost increases, resource scarcity and supply chain insecurity
- The *PB* framework offers an approach for companies to assess their impacts on the Earth System
- The *PBs* need to be made accessible for companies to use them practically at the scales within which they operate

Towards solutions: operationalising planetary boundaries thinking

In order for the *PBs* to be useful for a company they need to be applicable to global supply chains and be able to inform strategic planning and operational decisions.

For the *PB* framework to be useful to companies it needs to be applicable to scales that are relevant to business activities. The initial reflex is to “downscale” the *PBs* and explore what they mean within the scales at which a company operates. Another approach is “upscaling”, where the impacts of business activities at more local scales are translated into the global context.

These approaches have different advantages and disadvantages which are discussed below. This builds on an analysis of the challenges of applying the *PB* framework to companies with global supply chains which was published recently⁹. This work underlines the issues of applying the *PBs* to different geographic scales and identifies several areas of research that are needed to use the *PB* framework as a tool for corporate decision-making at different geographic scales.

4.1 The challenges of downscaling planetary boundaries to company level

Downscaling and providing limits (or targets) to actions and impacts at regional and local levels is an appealing approach because it could potentially inform the activities of companies and national governments. In this way, they could manage their contributions to transgressing the *PBs*. However, taking the *PBs* from global to local can be problematic because the science behind the construct of the *PB* framework is based upon the Earth System as a whole at a global level. Many of the *PB* processes are not readily scalable from the global to regional or local. The processes were designed to complement (not to replace) the methods and approaches that already exist for ecosystem management at local and regional levels. Additionally, the downscaling approach tends to lead to an assessment of what is a “fair share” for entities whether public or private, for example, how much action an individual company or country should take in terms of respecting the *PBs*. Once a *PB* has been transgressed there is, in fact, no “fair share” of the biosphere or the atmosphere left to exploit, no matter how a downscaling approach is applied in practice.

An analysis of the challenges of applying the *PB* framework to companies with global supply chains was published recently⁹.

This work agrees with the issues of applying the *PBs* to different geographic scales and identifies several areas of research that are needed to use the *PB* framework as a tool for corporate decision making at different geographic scales. This White Paper develops this further by considering an ‘upscale’ approach for corporate use.

4.1.1 Fair share and targets

In addressing the question of “fair share”, it is useful to separate the *PB* processes into two groups: first those whose control variables are generally well-mixed and thus consistent globally (*climate change, ocean acidification and stratospheric ozone depletion*); and second, those that have strong regional variations (*land-system change, biogeochemical flows, freshwater use, atmospheric aerosol loading and biosphere integrity*). *Novel entities* may show characteristics of both.

For the globally consistent control variables like that for *climate change*, there is a clear boundary that should not be transgressed no matter where on the planet a company is operating, i.e. an atmospheric concentration of 350ppm CO₂. Downscaling could be used as an approach that includes specific targets and application of a “fair share”, for example what is a company’s contribution to the 350ppm target. This could be undertaken by applying per capita equal shares, scaling according to income or wealth (either directly or inversely), perhaps scaling with the economic value of the activity, or taking learnings from the science-based target approach. Note, however, that at a current atmospheric CO₂ concentration of over 400ppm, the emphasis now is on how to get carbon out of the atmosphere rather than how much more CO₂ can be emitted.

For the *PBs* that have regional variations, the downscaling approach would need to be adapted. For example, the boundaries for *freshwater use* will be dependent upon the particular location; it does not make sense to downscale a global target across all regions when water scarcity varies considerably and the needs of freshwater ecosystems also vary. Similarly, the *land-system change* boundary varies according to the type of forest, so not all impacts on all forests are equal. Boreal and tropical forests have more stringent boundaries than temperate forests because they play stronger roles in the functioning of the Earth System.



4.1.2 Data needs

Any practical application of a downscaling approach requires more scientific knowledge and data. We need to be able to link the global scale datasets used to evaluate the *PBs*, and the processes they measure, to more local and regional data. Only then can they inform companies and other entities in the assessment of environmental performance.

Currently, data is not available at the resolution or level of certainty needed for local or regional scales, nor, sometimes, is the scientific knowledge needed to interpret that data in terms of process change (e.g., biodiversity loss). For example, there are reasonably large uncertainties around the amount of forest cover remaining in the world's major forest biomes. This level of uncertainty does not help individual companies and their supply chains identify if, where, and by how much they may be contributing to deforestation and the degradation of forests.

4.1.3 A word of caution

A strong caution is necessary for the downscaling approach as it tends to accompany a particular mindset. The temptation is to set targets or objectives at the level of the company, then focus strongly on meeting those targets. This mindset can result in the original critical assumptions made in the downscaling process being forgotten. There is a need to ensure that downscaling the *PBs* does not simply turn into another performance metric at the scale of the company or country, which could drive perverse consequences. A critical challenge here is that local and regional environmental regulations or considerations could overrule a downscaled *PB* approach. For example the need to protect a valuable local aquatic system could be more restrictive than that that would have been derived from a downscaled *PB*.

4.2 The opportunities of upscaling with planetary boundaries

Scaling up the activities and impacts of a company from local to the global level can help a company better understand how and by how much they may be contributing to the transgression of a *PB*. This 'upscaling' approach, whereby consequences of business driven environmental impacts at local and national scales are explored in scenarios at global scale within the *PB* framework, could be a suitable alternative to 'downscaling'.

Upscaling is focused on building outwards from a single company's actions and impacts towards the bigger picture of how it influences global processes. It would mean that, for example, local site-based impacts of supply chain activities such as agricultural production, mining operations and manufacturing processes are expanded or scaled up to consider their contribution to variables, processes and, ultimately, *PBs* at a global level. This would encourage companies to be more outward looking and emphasises the larger, global picture beyond a local or regional focus.

Upscaling approaches to assess global impact have already been used by other initiatives. For example, the Global Footprint Network assesses how many planets would be required to sustain all of humanity if they were to follow an individual's lifestyle, or the average

lifestyle of a "typical" citizen from different countries. Similarly, the activities and impacts of an individual company could be scaled up to demonstrate their total contribution to the *PBs*. Upscaling is often used in connection with the *climate change PB*; for example, if every country implemented policies like Australia currently has, we would be headed towards a 4°C world by 2100, far above the Paris 2°C target¹⁰.

4.2.1 Upscaling core planetary boundaries

The value of upscaling a company's impact can be exemplified through a focus on the two core *PBs*. The *climate change PB* is more straightforward to upscale (as noted above for Australia), based on the control variable of atmospheric CO₂ concentration. A company could estimate the CO₂ emissions resulting from its direct operations as well as its supply chain, and then upscale the estimated emissions to the sector as a whole. This approach enables a company to benchmark itself and deal with a more strategic approach to actions including:

- Is the company a leader or a laggard compared to others in the sector?
- What is the appropriate action for the company and its supply chain partners to reach 'net zero' emissions for its own operations and for its supply chain? What level of collaboration is needed to make this happen? Is it possible for the company to be a "net carbon absorber"?

Taking the other core *PB*, *biosphere integrity*, an upscaling approach could drive tangible and meaningful solutions. This could include an approach to deal with, for example, deforestation in one of the Earth's major biomes such as the Amazon Basin. A priority would be to phase out deforestation as rapidly as possible and, simultaneously, ramp up regenerative actions aimed at allowing forests to regrow on previously cleared land. Using this approach could support companies in answering questions such as:

- How much deforestation can be halted through changes in a company's own supply chain?
- How can a company influence the finance sector to divest from deforestation activities and invest in businesses that aim to undertake regenerative activities?
- How can a company influence others in its sector and beyond to move towards an overall ban on deforestation in the Amazon and to support regrowth activities?
- How can a company with local civil society implement their plans for sustainable economic activities in the Amazon that do not require deforestation?

4.2.2 Catalysing solutions

Upscaling could be a powerful way for companies to show how they understand the ultimate impacts of their actions globally as part of a sector and as an individual company. It allows for companies to take a perspective on the interconnectedness and ultimate consequences of their impacts rather than taking a single issue perspective. This broader approach provides the important context for them to highlight the positive solutions that they will implement and promote, and tends to foster innovative thinking and regenerative approaches as solutions (Figure 2).

The fact that four of the nine *PBs* have already been transgressed and that the Earth has entered the Anthropocene is a clear and strong indication that our economies need to move rapidly from being exploitative to being regenerative. The core *PBs* can help guide this, in concert with local and regional environmental policies and regulations. An obvious part of the way forward is, not only achieving net zero emissions, but developing ways to remove carbon from the atmosphere such as enhancing soil carbon storage in addition to ending deforestation and promoting widespread biome regeneration through re-forestation. Upscaling is important here as it changes the mindset from “how much is there left to exploit” to “what needs to be done to restore a well-functioning planet”? This also promotes cooperation across sectors and beyond, which is essential for successful implementation and replication of appropriate solutions.

PBs provide a framework to shift from a focus on meeting a single target aimed at solving a “single” challenge to setting a suite of targets that are formulated to address the interconnectedness of environmental challenges. It forces us to think about targets that address several challenges and about finding “multi-benefit” solutions that address these within and across companies and sectors. Halting deforestation in the tropical forests and the promotion of forest restoration will improve the condition of several *PBs*; (i) *land-system change* by conserving natural ecosystems, (ii) *climate change* through natural climate solutions that store more carbon and increase the resilience of the forest to disturbance; (iii) *biosphere integrity* by stopping biodiversity loss in this important biome (iv) *freshwater use* by increasing the regional recycling of water through enhanced evapotranspiration and rainfall; and (v) possibly the *atmospheric aerosol* loading boundary through reduced fire associated with deforestation.

An upscaling approach may enable significant questions not only to be raised, but also to be answered. These include:

- What if everyone in our sector behaved like us?
- How much impact would we have on the Earth System as a business and as a sector?
- If a *PB* has already been transgressed, what areas are the priorities that a company and sector focus on to stop ongoing negative impacts and move towards a regenerative approach?
- How can collaboration between companies and sectors help do this in order to share, on the one side, burden and risk and, on the other, opportunity?

4.3 Towards solutions – key takeaways

- Taking the *PBs* from global to local can be problematic because the science behind the construct of the *PB* framework is based upon the Earth System as a whole at a global level
- Downscaling is appealing but may encourage a “single issue” mindset
- Upscaling enables companies to consider a fuller picture of their impacts and where innovations can be taken to maximise opportunities
- Upscaling fosters a regenerative, big picture focus “single issue” mindset

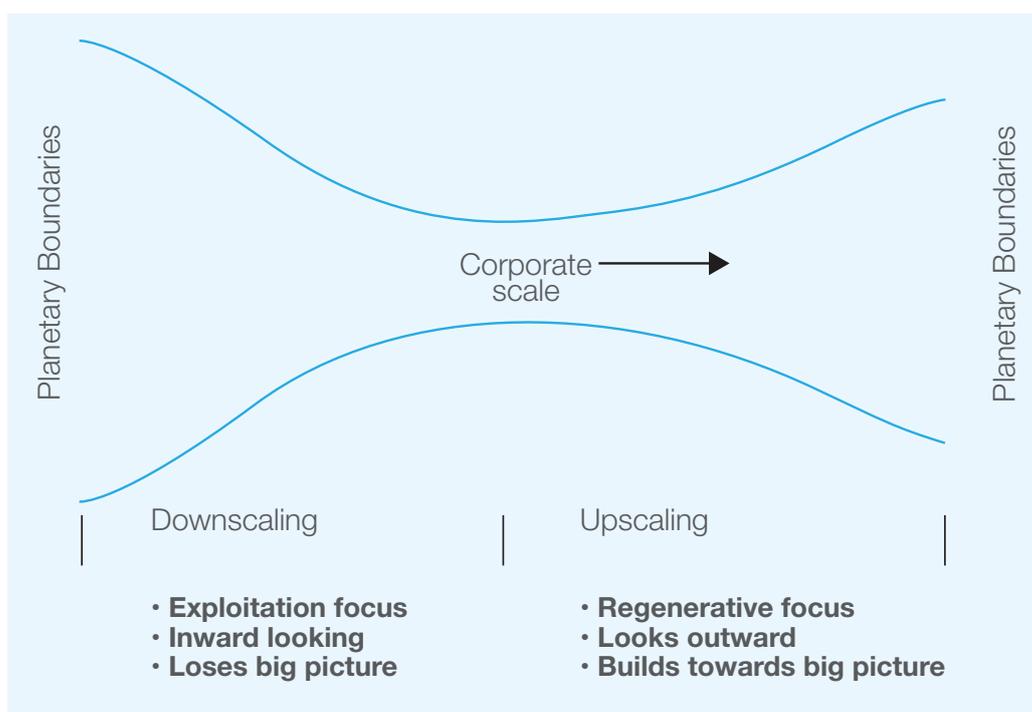


Figure 2: Downscaling versus upscaling planetary boundaries.

Possible next steps for the business community

The risks associated with humanity breaching the *PBs* are obviously significant for the business community and are becoming more and more apparent. However, the *PB* framework is at a scale that is currently not designed to be applied directly to business.

This White Paper has outlined the important opportunities as well as the not insignificant challenges associated with using the *PB* framework for corporate decision-making. Some of the aims of producing this White Paper are to underline the value of the *PB* framework for corporate sustainability, to validate the need to take a closer look at how the framework can be used and operationalised, as well as to catalyse discussion and action around this important topic. Ultimately, there needs to be a clear message to business on how to use the *PB* framework and to readjust their business approaches. In summary, there are three key challenges for this:

- The *PBs* are not independent but are highly interconnected
- Four of the *PBs* have already been transgressed
- Upscaling and downscaling approaches both offer interesting perspectives but both have significant challenges

5.1 First steps first

There is certainly a role that the business community along with other key experts can play in developing the *PB* framework as a tool to guide a new approach to sustainable business models. However, before companies can really engage on this issue there needs to be a basic understanding of business impacts and dependencies on natural capital. The real interface between a company and the control variables that measure the status of the *PBs* is across the supply chain, specifically at raw material sourcing. This is illustrated clearly in corporate natural capital accounting such as Kering's Environmental Profit and Loss (EP&L) account¹¹ where 90 percent of the Group's impacts lie in the supply chain and 66 percent of the total impacts are found in the production and processing of raw materials. Natural capital accounts such as the EP&L provide detail of where companies should prioritise their efforts to reduce their impacts on the natural environment. As resource scarcity and environmental degradation are becoming increasingly more

important to companies, these accounts can offer a strategic way of evaluating their risks and where the effects may be felt with business operations. Although advised, not all companies need to do detailed EP&Ls but they do need to recognise and fully understand the scope of their environmental impacts in their own operations and across their entire supply chain. Building on this, companies can then contribute to the new frontier of thinking and action that the *PB* framework provides; companies can engage further by re-designing corporate sustainability strategies to prioritise and address the *PBs*. The EP&L was indeed central in Kering's ability to become the first Luxury Group and first French based company to develop a science based target for its GHG emissions, approved by the SBTi.

5.2 Develop and incorporate upscaling approaches for company application of the planetary boundaries

Collaboration on designing ways to use the *PB* framework to set *PB*-associated goals or targets for companies and sectors is essential in order to provide companies with tools and guidelines they can implement operationally, including reviewing approaches that incorporate "upscaling".

By its nature, upscaling can encourage companies to work with government to set policies or regulations that tip the entire sector towards a regenerative approach. In this way, companies can not only influence others within their own supply chains but lead others in their sector to follow suit. In particular, the two core *PBs* – *climate change* and *biosphere integrity* – require an urgent shift from an exploitative to a regenerative approach. An upscaling approach tends to position a company as a leader or role model in a sector and it fosters innovative thinking.

It is recommended that this approach is explored and developed further. As such, further White Papers in Kering's series on Planetary Boundaries for Business will examine these areas.

5.3 Re-design company sustainability strategies to prioritise and address the planetary boundaries

Collaboration across sectors is required to consider how to deal with the *PBs* that have already been transgressed, and to develop whole-of-sector approaches to meeting the *PB* challenge. Meanwhile, there are some specific areas of focus for those wanting to embark on using the *PBs* to inform company sustainability strategies:

- An initial focus on the *PBs* where we already know that “sub-global” (e.g. regional) priorities and actions can be set. For example, the deep and rapid reduction of greenhouse gas emissions
- A focus on variables that play a significant role in stabilising the Earth System including those driving the *PBs* beyond the “safe operating space”. For example, loss of biodiversity and degradation and loss of the large tropical and boreal forests
- Prioritisation of business action on the “core boundaries” of *climate change* and *biosphere integrity* and agreement on bold actions at the level of company and sector to halt negative impacts that are causing these boundaries to be transgressed. As an example, there needs to be more focus on how companies can integrate action to improve *biosphere integrity*

One such example of new approaches that can help the focus on core *PBs* is the work of CISL’s Natural Capital Impact Group⁹. This group is developing a business appropriate indicator⁵ for supply chain impacts on biodiversity and this, in turn, will contribute to an understanding of a company’s contribution to the loss of *biosphere integrity*. Importantly, this new biodiversity indicator is based in part on the Biodiversity Intactness Index (BII)¹⁰, which is one of the two control variables chosen for the biosphere integrity *PB* (the other is extinction rate).

5.4 Possible next steps for the business community – key takeaways

- There is opportunity for companies to develop the *PB* framework for their own application to support business decision-making
- Exploration of an “upscaling” approach is recommended as a starting point
- Cross sector collaboration is required to determine corporate approaches to address the *PBs* that have already been transgressed

In dealing with these challenges, there is a significant opportunity for the business community to undertake transformational action around the *PBs* to help prevent further transgression of these boundaries and, indeed, to help reverse the current trends.



⁹ www.cisl.cam.ac.uk/business-action/natural-capital/natural-capital-impact-group/about

¹⁰ BII, originally created by Scholes and Biggs¹² and further developed by Newbold et al¹³, aims to estimate the degree to which the functioning of a modified ecosystem has been changed compared to the pristine ecosystem. BII can be applied at various scales, facilitating its use as an effective upscaling tool. In fact, a finer-scale regional mapping of BII could provide a focus for corporates wishing to take regenerative action as to the most appropriate areas for action, bearing in mind that there may be finer-scale environmental considerations that override the *PB*-derived ones.

Final word

The relationship between humanity and nature has fundamentally changed. In terms of the processes that ensure a well-functioning Earth System, they have already crossed critical boundaries.

The arrival of the Anthropocene epoch signals that we have moved from the concept of human society being a “*small world on a big planet*” to one of us being a “*big world on a small planet*”. We are rapidly and deeply undermining and destabilizing our own planetary life support system; we need new values and thinking, bold changes and innovative solutions. The traditional exploitative approach to the natural world, where it is viewed primarily as resources to be exploited and commoditised, needs to stop. This should be replaced by an approach that includes efficient and sustainable use of resources within the Earth System’s safe operating space, alongside a focus on regeneration and delivering positive outcomes for the environment. This approach should be founded on science with tangible milestones, targets and a system of monitoring and accountability. Companies, along with other global stakeholders, have a responsibility and an opportunity to contribute to the framing and implementation of this new approach.

The Planetary Boundaries framework is fundamental to designing our new agenda for managing and mitigating our global environmental challenges. Important components of the framework that reinforce its value include:

- **Science-based:** a peer-reviewed approach with ongoing input and improvement from a significant number of multi-disciplinary experts in addition to public and private sector engagement and commitment.
- **Prioritisation:** a way to set priorities for the critical, global-level challenges.
- **Not a “single issue”** implicit consideration of the inter-connectedness of the Earth System, processes, variables and outcomes.
- **Harmonisation:** contribution to illustrating the inter-connectedness of social and environmental targets through the SDGs and the ‘donut economics’ framework¹⁴.

There are significant challenges with adapting the *PBs* concept and framework, in its current form, into clear targets, actions and operational tools for the business community and the public and NGO sectors.

Initially, we need to determine how to take a concept developed at a global level and transform it into measurement and monitoring systems that can inform company actions at local and regional scales. This includes answering questions such as: What are the pros and cons of “upscaling” and “downscaling” for different sectors, impacts and actions? Secondly, scenarios and tools need to be developed that show how the actions and outcomes at a local or regional level impact the *PB* framework at a global level. This includes deciding on the appropriate focus by sector, by commodity, and by company. With this in hand, we then need to develop a new agenda for action which will include taking into careful consideration the local and national environmental regulations and policies.

Without a doubt there is work to do and challenges to overcome. However, the value of linking the *PBs* to business does make it imperative that we solve these challenges. The *PB* framework provides an appropriate new perspective for the design of solutions to global environmental challenges. Perhaps, most importantly, it can show companies that one cannot work only on solutions to “single issues”, no matter how large they may be, and that priorities may be different when developing solutions that address several challenges at once. In this way, companies can streamline their actions to address priorities and contribute to meaningful change at a global level. More profoundly, the *PB* framework can trigger a necessary shift in our thinking about our impact on the planet and our responsibility as individuals and as companies to change and create a more sustainable future.

Appendix

Glossary of terms

Earth System	A single complex system composed of interacting energy fluxes (e.g., energy from the sun) and physical, chemical and biological cycles. Humans, our societies and our activities are an integral part of the Earth System and not an outside force perturbing an otherwise natural system.
Holocene	The period representing the last 12,000 years during which the Earth System has been in a relatively stable state, with conditions that are particularly accommodating for human wellbeing and development.
Planetary Boundary (PB) framework	<p>An integrated framework based on a set of nine global-level biophysical processes that together define the state or condition of the Earth System as a whole. Although each of the nine processes is treated individually, there is much interaction among them.</p> <p>The nine processes are:</p> <ul style="list-style-type: none"> • Climate change • Change in biosphere integrity • Land-system change • Freshwater use • Biochemical flows • Ocean acidification • Atmospheric aerosol loading • Stratospheric ozone depletion • Novel entities
Control variable	A metric(s) that defines the state or condition of a particular <i>PB</i> process, such as carbon dioxide concentration for climate change.
Planetary Boundary	A position of the control variable beyond which there is an increasing risk of destabilising the Earth System.
Safe operating space	The state or condition of the Earth System that would be maintained if all nine of the <i>PBs</i> were respected (control variable is maintained below the boundary). This state would resemble the Holocene in many important features (e.g., climate).
Core PBs	<p>The <i>PBs</i> can be considered in two tiers. The core <i>PBs</i> are the only two <i>PBs</i> that, on their own, can drive a change in the state of the Earth System as a whole if they are transgressed.</p> <p>The core <i>PBs</i> are:</p> <ul style="list-style-type: none"> • Climate change • Change in biosphere integrity <p>These two core boundaries have already been transgressed, and the Earth System has entered a proposed new geological epoch, the Anthropocene</p>
Biosphere integrity	The capacity of the biosphere to (i) contribute to the stable functioning of the Earth System; and (ii) provide sufficient genetic material to allow the biosphere to continue to evolve.

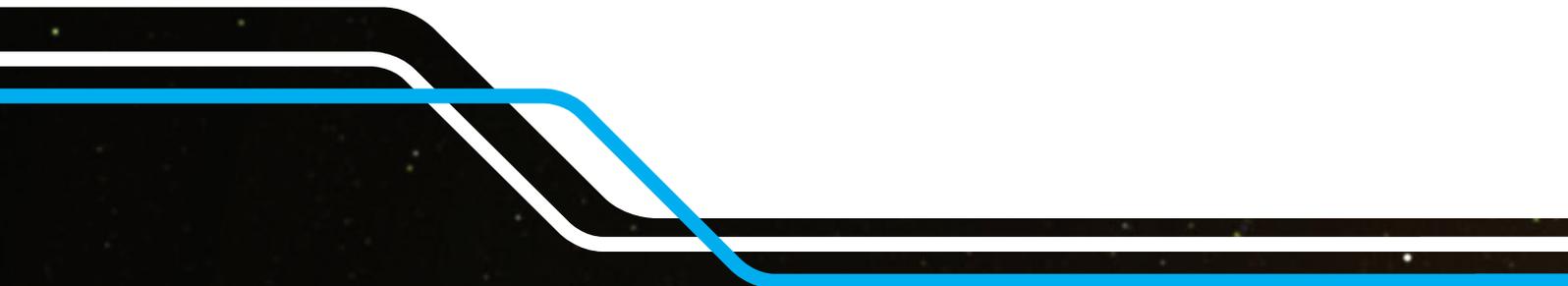
The implications of the planetary boundaries for business

Planetary boundary	Control variable		Status	Implications for business
	Global	Sub-global		
Climate change Global temperature has risen by nearly 0.7°C since 1950, mostly due to CO ₂ emissions from fossil fuel use.	Atmospheric CO ₂ concentration ppm		INCREASING RISK In zone of uncertainty	CO ₂ emissions must decrease, soon and sharply. Climate change, energy security and economic stability are tightly linked. Assets and business activity will be affected by rising temperatures, more frequent weather extremes, and sea-level rise.
Loss of biosphere integrity Wild animal populations have roughly halved since 1970, and ecosystems worldwide have been impacted by human activities.	<i>Genetic diversity:</i> Extinction rate <i>Functional diversity:</i> Biodiversity Intactness Index (BII)		HIGH RISK Beyond zone of uncertainty	Business cannot function if ecosystems are degraded or out of balance. Nature provides directly beneficial services – food, fibre, fuel. It also provides many invisible but essential services, such as regulation of climate and the water cycle, air quality improvements, flood protection. It also contributes to cultural and individual wellbeing.
Changes to biogeochemical flows – N and P are essential nutrients for all life. Exponential rises in N and P emissions from industry and intensive agriculture kill lake and marine life, cause severe air pollution and affect climate patterns.	<i>Nitrogen:</i> amount of N applied to land per year <i>Phosphorus:</i> P flowing into oceans	<i>Regional:</i> <i>Phosphorus:</i> P flow from fertilisers to erodible soils	HIGH RISK Beyond zone of uncertainty	Humanity faces a global challenge to produce more food and energy without eroding its ecological life-support systems. Global disparities in food and energy security are severe. The environmental release of N and P is becoming an unaffordable waste of natural resources.
Land use change (forest conversion to croplands, roads and cities) As well as killing wildlife, deforestation and urbanization affect climate by changing CO ₂ flows	Area of forested land as % of original forest cover	<i>Biome:</i> Area of forested land as % of potential forest	INCREASING RISK In zone of uncertainty	Business has caused a significant part of the world's large-scale land degradation and deforestation. It can make a major difference by adopting and promoting sustainable land management practices and policies.
Release of novel entities Synthetic substances – and even novel life-forms – can radically alter Earth's biological and physical dynamics, bringing entirely new systemic risks to human societies.	No control variable currently defined		Boundary not yet quantified	Business plays a unique role as the producer of novel entities, many of which are essential in modern society (medicine, agriculture, consumer goods, new technologies). Urgent reduction in releases of harmful substances means a renewed focus on sound chemicals management by business.
Atmospheric aerosol loading Microparticles emitted into the air cause severe local pollution problems that can cascade up to global impacts on nature and climate.	Aerosol Optical Depth	<i>Regional:</i> Aerosol Optical Depth as a seasonal average over a region	Boundary not yet quantified	Atmospheric aerosols have complex impacts, but all business action to address air pollution at the local level to is likely to help tackle the systemic global problem too. Avoid “exporting pollution” by shifting manufacturing to places with lax regulatory controls.
Freshwater abstraction Water use impairs or even dries up rivers and aquifers, harming the environment and altering the hydrological cycle and climate.	Amount of blue water use	<i>Basin:</i> Amount of blue water withdrawal as % of mean monthly river flow	SAFE Below boundary	All business action at the local level to minimise water waste and reduce the release of pollutants into the environment will help to reduce pressure on the planetary boundary.
Ocean acidification Tightly coupled to climate change through absorption by oceans of CO ₂ and formation of carbonic acid, today's rate of ocean acidification is unprecedented in over 65 million years. Early effects on marine life are becoming evident.	Carbonate ion concentration		SAFE Below boundary	The rise in carbon dioxide emissions must halt – and the sooner, the better. Delaying the CO ₂ emissions peak will require higher mitigation rates, with higher costs and higher climate risks.
Loss of stratospheric ozone The ‘ozone hole’ allows more harmful UV light to reach Earth's surface. The minimum ozone concentration has now been steady for ~15 years after the phasing out of ozone depleting substances.			SAFE Below boundary	This is often seen as a success story, but the good work to reduce environmental release of ozone depleters must continue. Avoid “exporting pollution” by continuing use of these substances in places not yet subject to international regulatory controls.



References

- ¹ Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, III, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. and Foley, J.A. (2009). A safe operating space for humanity. *Nature*, 461, 472-475.
- ² *Sustainable development knowledge platform* (2017) Retrieved from United Nations website, <https://sustainabledevelopment.un.org/>
- ³ CISL. (2015) *Rewiring the Economy*. Cambridge, UK: Cambridge Institute for Sustainability Leadership. <https://www.cisl.cam.ac.uk/publications/low-carbon-transformation-publications/rewiring-the-economy-ten-tasks-ten-years>
- ⁴ Di Fonzo, M., & Hime, S. (2017). *How businesses measure their impacts on nature: A gap analysis* (Vol. Working Paper 01/2017). Cambridge, UK: Cambridge Institute for Sustainability Leadership.
- ⁵ Di Fonzo, M., & Cranston, G. (2017). *Healthy ecosystem metric framework: biodiversity impact*. (Vol. Working paper 06/2017/0. Cambridge, UK: Cambridge Institute for Sustainability Leadership.
- ⁶ Natural Capital Coalition. (2016). *The path towards the Natural Capital Protocol: A primer for business*.
- ⁷ Hoff, H., Häyhä, T., Cornell, S. and Lucas, P. (2017) *Bringing EU policy into line with the Planetary Boundaries*. Stockholm Environment Institute and Stockholm Resilience Centre.
- ⁸ Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., and Sörlin, S. (2015) Planetary Boundaries: Guiding human development on a changing planet. *Science*, 347. doi: 10.1126/science.1259855
- ⁹ Clift, R. et al. (2017) The challenges of applying Planetary Boundaries as a basis for strategic decision-making in companies with global supply chains. *Sustainability*, 9. doi:10.3390/su9020279
- ¹⁰ Climate Action Tracker (2017) Australia. Accessed at <http://climateactiontracker.org/countries/australia.html>
- ¹¹ *Environmental P&L*. (2017) Retrieved from Kering <http://www.kering.com/en/sustainability/epl>
- ¹² Scholes, R.J. and Biggs, R. (2005) A biodiversity intactness index. *Nature*, 434, 45-49.
- ¹³ Newbold, T., Hudson, L. N., Hill, S. L. L., Contu, S., Lysenko, I., Senior, R. A., . . . Purvis, A. (2015). Global effects of land use on local terrestrial biodiversity. *Nature*, 520 (7545), 45-50. doi: 10.1038/nature14324 <http://www.nature.com/nature/journal/v520/n7545/abs/nature14324.html#supplementaryinformation>
- ¹⁴ Raworth, K. (2017) *Doughnut Economics: Seven Ways to Think Like a 21st Century Economist*. Random House Business Books, London



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