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Planetary Boundaries: measuring the business world's environmental footprint

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IN PARTNERSHIP WITH

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Sustainability Science for Biosphere Stewardship

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Foreword

Businesses have a huge role to play in containing global environmental risks. And because they have great leverage on companies, so too do investors.

The idea of "ethical" or "green" investing has gained ground in recent years, but it is hampered by a lack of quantitative definitions.

We propose that the Planetary Boundaries framework, devised by Rockstrom et al. in 2009, is a good starting point.[1]

The framework takes nine dimensions of planetary health – measurable criteria such as concentrations of greenhouse gases, or biodiversity loss. It then attempts to establish how far each of these can change without risk of provoking sudden, irreversible damage to the environment.

We have also developed a way to apply the Planetary Boundary framework to investment decisions; specifically,

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we quantify the environmental impact for every USD1 million of annual revenue businesses generate.

If a company's activities lie within the safe levels for each of the nine dimensions over the whole of the product value chain, then the firm (and potentially its stocks and bonds) can be viewed as being environmentally sustainable; if not, then the business is likely to be speeding up global environmental degradation.

1 Source: https://www.ecologyandsociety.org/vol14/iss2/art32/

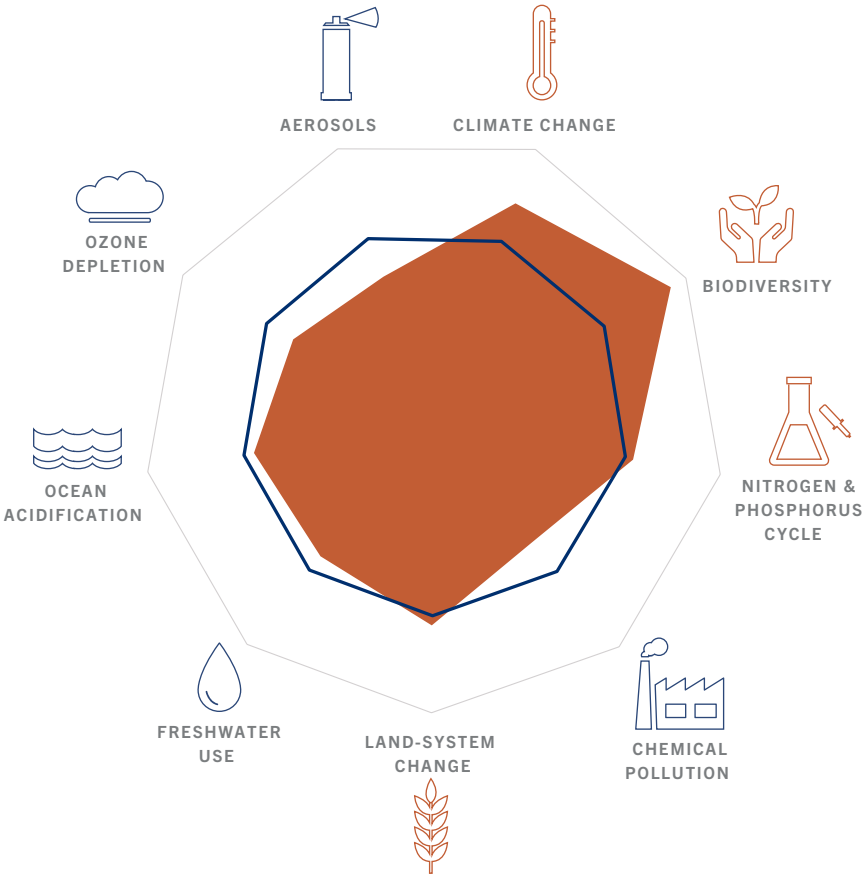
This is a non-technical summary of the paper by Butz, C., Liechti, J., Bodin, J. et al. Towards defining an environmental investment universe within planetary boundaries. Sustain Sci 13, 1031–1044 (2018. https://doi.org/10.1007/s11625-018-0574-1)

The nine dimensions of the Planetary Boundaries framework are: climate change, biodiversity loss; biochemical flows; chemical pollution; land-system change; freshwater use; ocean acidification; ozone depletion and atmospheric aerosol loading.

We will examine each of them in turn, suggesting changes that we think are necessary to make the metrics more relevant to the investment process.

Investment is often focused on short-term metrics, while planetary health demands a long-term horizon. We have chosen short-term, local metrics that have long-term, globally systemic consequences. But we acknowledge that this also implies an assumption that incremental changes are sufficient to maintain planetary health.

PLANETARY BOUNDARIES FRAMEWORK



SAFE OPERATING SPACE
CURRENT ECONOMIC INTENSITY

CLIMATE CHANGE
Ever-increasing GHG emissions accelerate global warming, which threatens to change global precipitation patterns, cause sea levels to rise and increase the severity of storms

BIODIVERSITY
Loss of species several orders of magnitude higher than the natural background rate, gravely endangering our natural "life support systems"

NITROGEN & PHOSPHORUS CYCLE
Human fixation of atmospheric N has reached an unprecedented scale with serious detrimental consequences (health impacts, eutrophication, global warming and ozone layer depletion)

CHEMICAL POLLUTION
Planetary boundary not yet quantifiable, but scientists agree that the level of pollution is already too high and disruptive to health and ecosystems

LAND-SYSTEM CHANGE
Conversion of forests and other natural habitats for intensive agricultural or industrial production releases GHG and degrades ecosystems

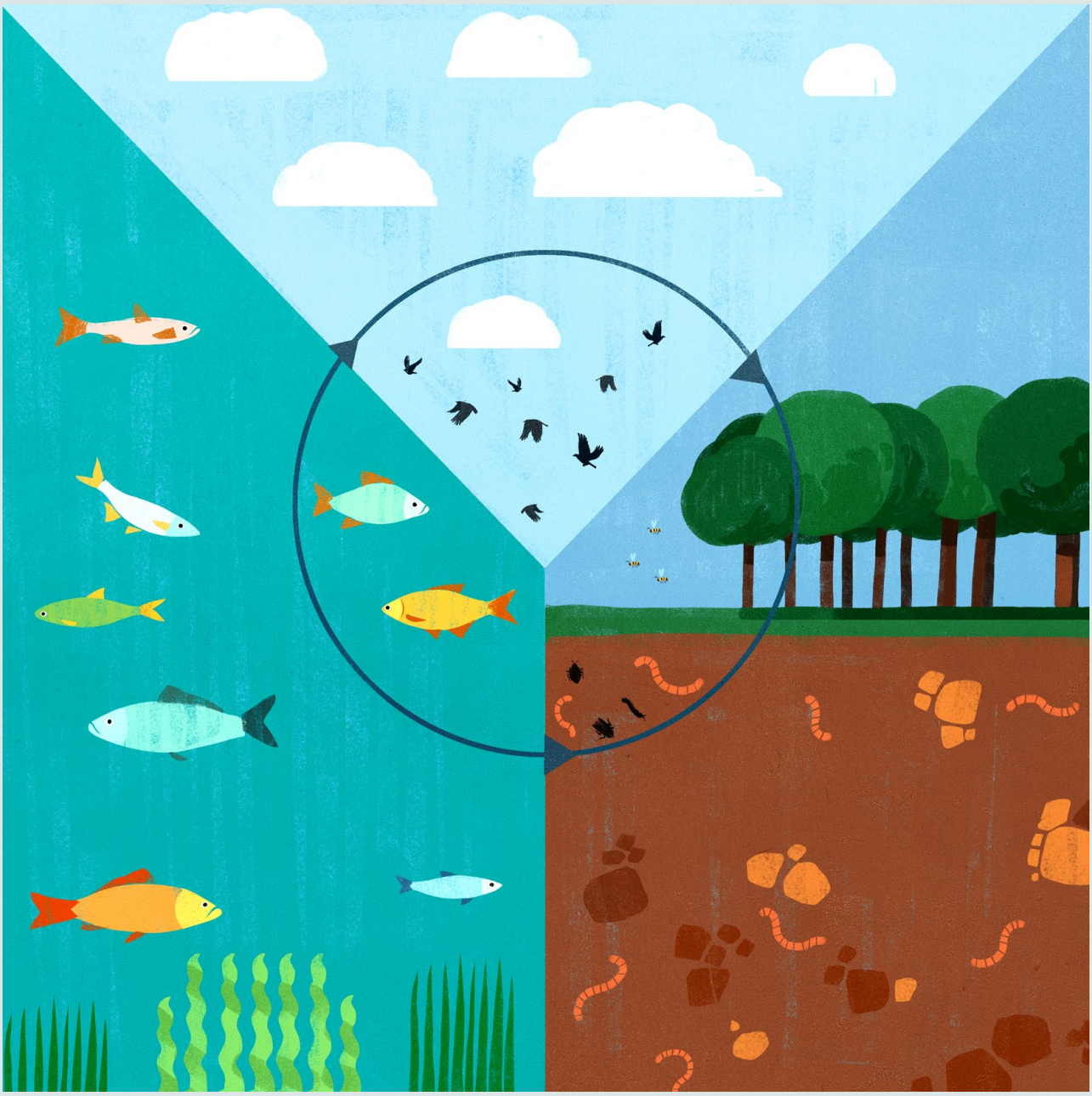
FRESHWATER USE
Water is overused and heavily polluted in many regions of the world, with dire consequences on ecosystems, human health and economic production

OCEAN ACIDIFICATION
Deposition of acidic compounds into the oceans depletes their buffer capacity for CO_2 and impacts heavily on shell-forming organisms, and thus the entire marine food web

OZONE DEPLETION
Ozone-depleting substances destroy the stratospheric ozone layer, often after complex photochemical processes with heavy consequences for human health and other plant and animal organisms

AEROSOLS
Quantification not yet possible, but heavy loading with airborne particles is already impacting human health, climate and ecosystems

Source: Pictet Asset Management, Stockholm Resilience Centre



Planetary Boundaries in depth

Climate change

The overwhelming scientific consensus is that greenhouse gases generated by human activity – primarily carbon dioxide, methane and nitrous oxide – are the dominant cause of the global warming observed since the mid-20th century.

The Planetary Boundaries framework measures our impact on climate change in atmospheric concentrations of greenhouse gases and their heat-trapping effects.

In itself, this is not useful for investors, because it focuses on the end state, not the amount of greenhouse gas emitted per unit of economic activity.

Instead we propose a pragmatic simplification.

In order to keep global warming to below 2°C from pre-industrial temperatures, the United Nations Framework Convention on Climate Change says that an allowable emissions level is equivalent to 14.25 billion tonnes of CO_2 per year globally. That is about one-third of current emissions levels. Dividing that figure by annual world economic output of USD75.6 trillion, we reach a boundary threshold equivalent to 188.5 tonnes of CO_2 per million US dollars of output. The current level is 639 tonnes per million US dollars, meaning that emissions will have to drop by 70 per cent. And as the economy grows, that figure will have to fall further.

Biodiversity loss

Human activity, not least resource extraction and the expansion of agricultural and pastoral land, has accelerated the loss of plant and animal species. Measuring the rate of actual and natural extinction – or, indeed, even having a clear idea of how many species there are – is fraught with difficulty. But given the possible range at which they occur, the Planetary Boundaries model estimates that the yearly safe rate of extinctions is below 10 extinctions per one million species. Our calculations show that the extinction rate must be less than 0.13 per million species for every USD1 trillion of corporate revenue generated. The current pace is estimated to be around ten times higher than the threshold level.

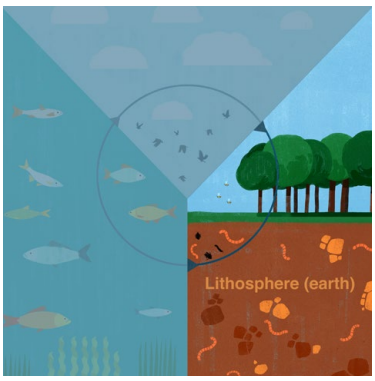
Biogeochemical flows

Nitrogen (N) and phosphorus (P) are macronutrients used extensively in fertilisers. Intensive farming, industrial activity and population growth have increased the quantity of both in rivers and oceans to dangerous levels, frequently triggering rampant growth of algae. This is damaging to the ecosystem because algae deplete oxygen in water, killing aquatic plants and fish.

We translate P into N-equivalents, and come up with a Planetary Boundary of 142.3 million tonnes of N-equivalent per year. Currently, the flow is 205.7 million tonnes per year, exceeding the boundary by a factor of 1.44. In order to bring the flow of macronutrients back into ecological balance, companies should not emit more than 161kg per million dollars of annual revenue.

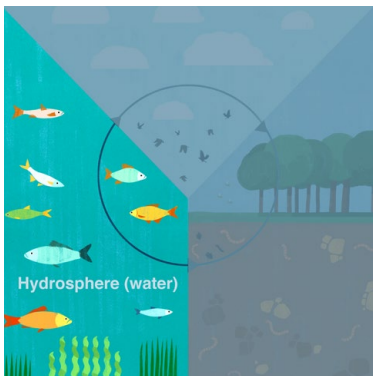
Chemical pollution and environmental release of novel entities

As with aerosols, the literature suggests that chemical pollution is a vital indicator of planetary health, but does not give a quantitative boundary. Chemical pollution comes in many forms – pesticides, heavy metals, hormones, antibiotics are pollutants when used excessively. Following the same approach we used to calculate aerosol loading, we took criteria such as toxic releases into the air, surface water, underground water and soil, by kilogram, and ecotoxicity and human health impacts, and again created a virtual metric, n-kg CP, calibrated as 1/1000th of the current level, and set the Planetary Boundary at 3000 n-kg CP per million US dollars, i.e. at three times the current emissions level. As for aerosols, this may be an overly generous boundary, but in the absence of scientific quantifications for a stronger constraint, we have opted to start with this flexible approach.



Land-system change

Land is the ultimate scarce resource. Forests, in particular, are vital to the climate system and biodiversity. Our calculations show humans must not convert any more than 8.3 billion of the world's 13 billion hectares of available wooded areas if we are to maintain a healthy and sustainable environment. Once we have made adjustments for the fact that agricultural land is largely converted from one-time forests, this translates to an acceptable usage of 33 hectares per million dollars of annual revenue. Current use is 39 hectares per million dollars, which means we have breached the boundary.



Freshwater use

Human interference with the freshwater cycle – whether through agriculture, industrial use or poor wastewater management – has negative effects on water availability, ecosystems, health, and food security.

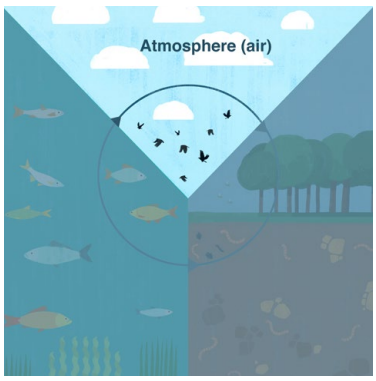
Rockstrom et al. suggest that up to 4,000km^3 of the world's freshwater supply can be extracted per year without transgressing this Planetary Boundary. However, not all water use is extraction, as some freshwater is also polluted through toxic releases into ground or surface water; the ratio of withdrawal to other consumption is given as 1.53. Applying this to the extraction level gives a Planetary Boundary of 6,154km^3 of water per year. At a company level, this implies a water withdrawal boundary of 81,408 m^3 per million US dollars of annual revenue. Currently, withdrawal stands at 29,106 m^3 per million dollars, meaning we are within the boundary.

Ocean acidification

As CO_2 concentrations, and those of other pollutants, increase, oceans become more acidic. Increased acidity stops calcium-carbonate skeletons and the shells of various marine organisms from forming properly. This affects both the biosphere and the health of economically important fisheries and shell fisheries.

The Planetary Boundaries framework looks at the marine saturation of a form of calcium carbonate called aragonite. Yet because this does not give an indication of the industrial processes behind acidification, it is not particularly useful for making investment decisions.

Instead, we consider the emissions of four acidifying substances – CO_2, NO_2, SO_2 and NH_3 – and the rate at which they form acidifying H3O+ ions in the ocean. Using some simplifying assumptions, we give a total ocean acidification economic intensity of 0.0370 kmol H3O+ per million US dollars. Our calculations show the current rate of acidification is 0.0282 kmol H3O+ per million dollars, which means we have not breached this boundary.



Stratospheric ozone depletion

Ozone in the stratosphere protects us by filtering out life-threatening ultraviolet radiation from the sun. In the early 1980s it became clear that human emissions of ozone-depleting substances, such as CFCs, had breached a threshold and caused a chain reaction, opening up a large hole in the ozone layer over the Antarctic. The 1987 Montreal protocol banned the most harmful substances, and emissions have since slowed. The boundary is no longer being transgressed, although the hole will remain for several more decades.

The 1980 level of emissions, the equivalent of 6.6 billion tonnes of CFC-11, was low enough to maintain stratospheric ozone levels steady. Dividing that figure by global GDP tells us that 2.48 kg of CFC-11 equivalents per million US dollars of revenue is the limit for allowable ozone depletion. The current rate is 1.05 kg per million dollars, well within boundaries.

Atmospheric aerosol loading

The concentration of small airborne particles – be they soot, chemicals, metals or biologically derived dust – in the atmosphere should be considered a key environmental dimension, but the scientific literature does not give a quantitative boundary. Such particles influence the climate system, hydrological cycle and atmospheric chemical processes, as well as having negative effects on the health of animals and plants. Our model takes seven indicators and has weighted them to give a virtual aerosol unit, n-kg AE, by first setting the current total at 1,000 n-kg AE. We then set the boundary at 3000 n-kg AE per million US dollars, i.e. at three times the current emissions level. This might seem a rather permissive approach, but any boundary is more restrictive and useful than no boundary at all, and our model can be very easily and quickly adjusted as new scientific insights emerge.

Planetary Boundaries for investment

There is a vast trove of data generated by some 70,000 companies globally that make public their accounts. The data go far beyond the nuts and bolts of their profits and losses – they offer the potential for real insights into the impact the corporate sector has on the wider environment.

But trying to paint a coherent picture company by company is nigh impossible. Instead, we have developed a model that divides the corporate world into 16 sub-industries. Each of these sub-industries is then appraised in terms of the impact it has on the nine dimensions of the Planetary Boundary framework.

We scrutinise the environmental footprint of industries across their entire value chain: from the extraction of raw materials to manufacturing processes, distribution and transport, product use and disposable and recycling.[2] Take the car industry for example. Cars produce CO_2 emissions at the production process, but they generate more pollution and emissions after they have left the factory and rolled onto the streets.

We also fine-tune our analysis according to industry-specific factors. For instance, environmental service companies may generate large amounts of emissions when they incinerate waste, but they are also remediating existing pollution from others.

We believe our framework gives investors a new way of tracking the sustainability of companies – especially in relation to their impact on key environmental challenges that are facing our planet. Our model helps highlight those that actively make a contribution to solving environmental problems and help others reduce their footprint. These are the companies that form part of what we could consider a responsible investment universe.

2 In order to conduct the analysis from the entire value chain perspective, use Carnegie Mellon University's economic input-output life cycle assessment database (EIO-LCA), then supplement with environmental and economic information from the World Bank.

Stockholm Resilience Centre (SRC)

The SRC is an international research centre on resilience and sustainability science. Established in 2007, it has conducted world-leading research to address complex challenges facing humanity.

The centre is a joint initiative between Stockholm University and the Beijer Institute of Ecological Economics at the Royal Swedish Academy Sciences.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