



PUBLICATION OF “SAFE AND JUST EARTH SYSTEM BOUNDARIES”

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What this is

- The “Safe and Just Earth System Boundaries” is a peer-reviewed paper being published in *Nature* on 31st May 2023.
- This science has been produced by the Earth Commission, the scientific cornerstone of the Global Commons Alliance, and co-authored by Johan Rockstrom, Joyeeta Gupta and Prof. Qin Dahe.

Further resources

- The full manuscript can be accessed [HERE](#) when the embargo lifts.
- Simple language breakdowns of the boundaries can be accessed here: [Aerosols](#); [Climate](#); [Freshwater](#); [Fertilisers](#); [Biodiversity](#)
- A high resolution visual can be downloaded [HERE](#).

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PRESS RELEASE

New research quantifies the conditions needed for communities and economies to thrive - and provides guide for leaders to operate within Earth's finite limits

31st May 2023

- Safe and Just Earth System Boundaries provide one of the most holistic measurements of Earth's finite limits, and mark a step change in understanding how to protect people and planet.
- New quantifications of the limits of Earth's vital systems (such as climate, biodiversity, water and air) include *impacts on people* - measured for the first time in the same units as planetary stability.
- The findings underscore the urgent need for action across all Earth's vital systems, the injustice inherent in current world targets, and the need for just transformations.
- The analysis is set to become the scientific backbone of the next generation of sustainability targets and practices, which are broadening their focus beyond climate, and is aligned with the recently published 'science based targets for nature' by the Science Based Targets Network.
- Leaders call on the public and private sectors to urgently adopt the boundaries in their sustainability efforts, to mitigate risk and create the conditions for thriving societies and economies.

New research published today in Nature defines a set of Earth System Boundaries that scientifically quantify safety of people as well as stability of the planet - which until now have not been measured in the same units. This work builds on existing knowledge and marks a leap in understanding of how to protect the planet's finite resources and create the conditions necessary for communities and economies to thrive.

Co-authored by over forty leading natural and social scientists from the **Earth Commission**, and led by **Prof. Johan Rockström**, **Prof. Joyeeta Gupta** and **Prof. Qin Dahe**, the Safe and Just Earth System Boundaries provide a scientific foundation for assessing the stability and resilience of the planet and the connection therein with human wellbeing. These Earth System Boundaries can guide companies and governments in evaluating risks, performance and opportunities as they navigate urgent efforts to achieve a net zero, nature positive and equitable future, especially in combination with just transformation practices.

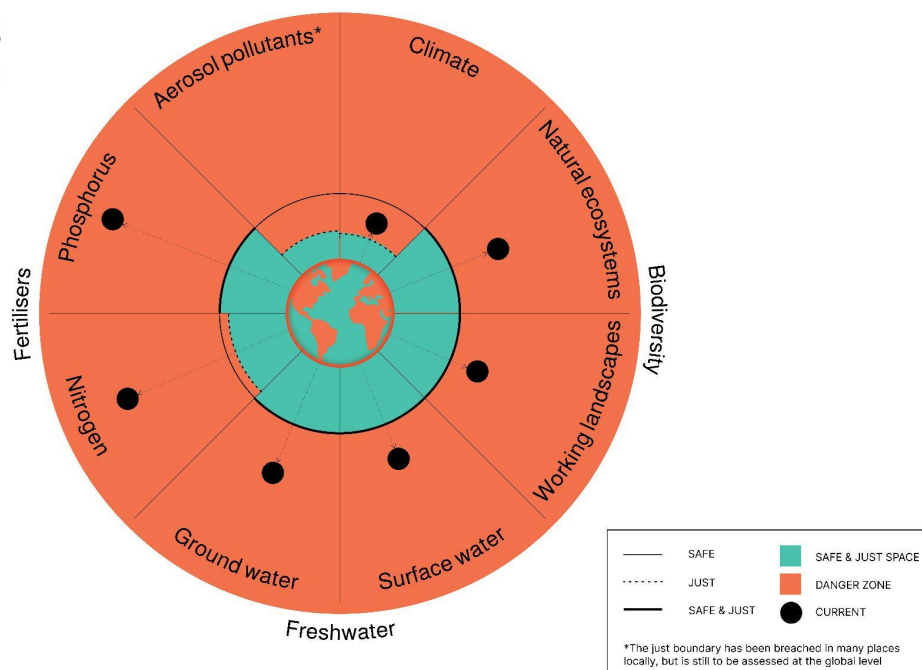
The Earth Commission was established by the **Global Commons Alliance** – a coalition of 70+ leading organisations working to safeguard the global commons, including the **World**

Economic Forum, World Business Council For Sustainable Development, The Nature Conservancy, Capitals Coalition, and Future Earth - which hosts the scientific secretariat of the Earth Commission.

The Earth System is made up of many interconnected processes that keep our planet stable or - when disrupted - radically alter its ability to provide a habitable environment. The Earth Commission's research explores processes in *climate*, *air*, *water* - both ground and surface water - *biodiversity* - within natural ecosystems and working landscapes - and *fertilisers* - both nitrogen and phosphorus.

While previous research such as the 'Planetary Boundaries' have studied the 'safe' limits of these processes, this is the first to incorporate 'justice' into scientific analysis, using the same units of measurement. This means the scientists identified limits at which humans are protected from significant harm resulting from planetary changes. These 'just' boundaries are in some places more stringent than the 'safe' boundaries. Additional work from the Commission identifies the conditions needed for people to access resources for a dignified life.

Safe and Just Earth System Boundaries



Almost all of the Safe and Just Earth System Boundaries have been breached, adding urgency for accelerating action to meet existing sustainability goals, including the Paris Agreement for climate, the Kunming-Montreal Global Biodiversity Framework, and the 2030 Sustainable Development Goals. This science emphasises that these goals must also be achieved in a just manner.

Prof. Johan Rockström, Director of the Potsdam Institute for Climate Impact Research and co-author of the report, said: “All the models today that take us to net zero assume that nature will continue to provide buffering capacity against global warming. There are nine biophysical processes and systems that regulate the state of the Earth System - the Planetary Boundaries – the Earth Commission took six of these and scientifically quantified them with safety and justice considerations to indicate a safe landing zone for people and the planet. Working holistically across these domains is crucial to our ability to reach net zero.”

Prof. Joyeeta Gupta, Professor of Environment and Development in the Global South at the University of Amsterdam and co-author of the report, said: “Justice is a necessity for humanity to live within planetary limits. This is a conclusion seen across the scientific community in multiple heavyweight environmental assessments, including our own. It is not a political issue. Overwhelming evidence shows that a just and equitable approach to both goal setting and transformation to achieve the goals is essential to planetary stability. We cannot have a safe planet without justice. Anyone building a resilient company, institution or nation for the long term must work towards this future.”

Prof. Dahe Qin, Co-Chair of the Earth Commission and Director of the Academic Committee, Chinese Academy of Sciences and co-author of the report, said: “The Earth System is in danger, as many tipping elements are about to cross their tipping points. So far, seventeen tipping elements are identified in scientific literature, among them, nine are cryosphere-related. The Asia High Mountain Cryosphere (AHMC) for example is fast changing and close to becoming a new tipping element, which can impact the regional social-economy.”

Prof. Xuemei Bai, Distinguished Professor, Australian National University, and co-author, said: “This study brings into focus the human dimension of the climate debate. In putting a number on human needs and impacts, it shows how the protection of the planet is inseparable from the success of communities, societies and economies. These Boundaries enable businesses to understand their fair share of resources and responsibilities, and to take measurable action to minimise their footprint on the planet that also helps improve human wellbeing.”

A call for leadership

As the most up-to-date understanding of the planet’s limits to supporting thriving societies, the Safe and Just Earth System Boundaries are set to become the scientific underpinning for the next generation of sustainability targets, expectations and actions. For example, the **Science Based Targets Network** - a group of organisations providing tools for companies to transform their impact on nature - has just released its first iteration of targets for water and land, which are informed by the scientific literature, and are now being road tested by seventeen major companies. By designing sustainability efforts around the Safe and Just Earth

System Boundaries and just transformation, business leaders will be able to stay ahead of scrutiny, remain competitive, and thrive in the long term.

“This science is critically important for business. It connects climate to nature, freshwater, clean air and other global commons and defines what is needed to secure our collective future. It highlights how the current trajectory is untenable for the global economy and society. Businesses will face interacting crises and escalating risks in their operations and supply chains, which will destroy value. This new research will become the scientific underpinning for how businesses can and should build strategy, set targets and implement action to mitigate the risks and exercise leadership to safeguard the conditions for their continued success.” said **Gim Huay, Managing Director, Centre for Nature and Climate at the World Economic Forum**

Setting a course for the ‘Safe and Just space’

This emerging science quantifies both the influence of humans on the Earth System, and the influence of the Earth System on humans. Building on existing frameworks, it integrates a justice perspective for the first time - which includes minimising human exposure to significant harm, and ensuring access to the resources needed for a dignified life and freedom from poverty for everyone.¹ By quantifying these conditions in the same units of measurement as the conditions for stability, the scientists say they have defined the Safe and Just Boundaries.

Of the eight boundaries, human activities have pushed seven beyond their Safe and Just limit and into the risk zone - threatening both planetary and human health. This highlights the urgent need for global leadership, rapid decision-making and just transformation toward a ‘Safe and Just space.’

Transforming our economies to operate within the limits of the planet offers huge opportunities for business leaders to stay ahead of regulatory scrutiny, meet the expectations of an increasingly conscious consumer and stakeholder base, and protect the communities, economies and natural resources upon which their operations depend. These boundaries allow leaders to see a more complete picture of the risks they face and supercharge their sustainability efforts, with a comprehensive framework for measurement and action that can be applied across markets, at both national and regional level. Global businesses including **AB InBev, Carrefour, GlaxoSmithKline PLC, H&M Group, Holcim Group, Nestle** and **Tesco** are now setting science-based targets for nature alongside their climate targets, informed by the same science that Earth System Boundaries have drawn from.

¹ Significant harm is defined as: widespread severe existential or irreversible negative impacts on countries, communities and individuals from Earth System change, such as loss of lives, livelihoods or incomes, displacement, loss of food, water or nutritional security, chronic disease, injury or malnutrition.

This work is more prescient than ever following the recent IPCC AR6 Synthesis Report, which stressed that - despite the richest 1% of the world's population being responsible for double the CO2 emissions of the poorest 50% - climate change has increased inequality, and will continue to do so without action. This science will equip leaders to build justice and human wellbeing into their decision-making on sustainability.

Appendix 1.

SUPPORTIVE QUOTES FROM BUSINESS AND CLIMATE LEADERS

Razan al Mubarak, UN Climate Change High-Level Champion from the COP28 Presidency; President of the International Union for Conservation of Nature:

"We are in a race to net zero and a race to resilience for our climate. We also need to be in a race to nature if we want to secure a safe and just future for all people. These Earth System Boundaries provide an important scientific underpinning for that race, and provide multiple different entry points for businesses to strengthen their climate action. Urgent, integrated action is key and the time to start is now."

Marc Benioff, Salesforce Chair and CEO:

"As global citizens and businesses, it's our collective responsibility to respond to this planetary emergency. That's why I'm so excited about the important work of the Earth Commission to measure the impacts of nature on the wellbeing of all people and the resilience of economies. This research unlocks a critical new way of thinking about the business case for protecting the planet and taking actions that will safeguard it for the generations to come."

Christiana Figueres, former Executive Secretary, UNFCCC, co-founder of Global Optimism, and co-host of Outrage + Optimism:

"In 1992 humans created the Biodiversity and Climate conventions for multilateral action, and for too long we've assumed that these issues were separate from each other. That separation has guided government and corporate acting and thinking on the environment for the past thirty years. What this new science makes clear is that the Earth System is not made from separate building blocks: everything is interdependent, including human beings. The urgency to act is not new - we know we are breaking

boundaries - but the insight from this groundbreaking science: that if we act holistically and put human wellbeing and equity at the centre we can have a safe and just space on Earth for all future generations, gives us even more reason to be stubbornly optimistic such a future is possible. I hope this science creates a real mindset shift for government and corporate action".

Paul Polman, business leader and co-author of 'Net Positive: how courageous companies thrive by giving more than they take', former CEO of Unilever:

"This robust and comprehensive science will allow governments and industry to understand and improve – for the first time – their impact on our Earth against human boundaries as well as biophysical, Planetary Boundaries. In practice, for CEOs, taking this people-centric approach is going to mean more ambitious and urgent targets and actions. Following the research, as we should, will mean setting the bar higher, but ultimately setting it where it belongs, with human-beings at the heart of our collective efforts to build a better and safer future for all."

Sharan Burrow, Former General Secretary of the International Trade Union Confederation:

"To counter unacceptably high levels of insecurity and inequality, we need an economic model that protects nature and people. A just transition to a sustainable economy would create reliable jobs and shared prosperity. By quantifying the future needs of humans as well as those of the planet, the Earth System Boundaries give us the scientific framework we need to work towards that goal with all our strength."

Ani Dasgupta, President & CEO of World Resources Institute

"The climate and nature crises we are facing today at 1.2 degrees of warming have already breached the 'just' boundary, disrupting millions of lives in the most vulnerable parts of the world. Equity must be central in our response to these crises. Every fraction of a degree of warming has a direct impact on people's lives and livelihoods, from undermining food security and displacing families from their homes to increasing the risk of disease and so much more. There has never been a more urgent need for leaders to take transformational action to limit global warming, protect nature and build a just economy for all."

Eva Zabey, CEO of Business for Nature:

“All businesses operate within, not separate from, earth systems. Our economies and livelihoods fundamentally depend on vital planetary stability, which is at major risk. Corporate decision-making and strategy must be grounded in just earth system boundaries, in order to contribute to a nature-positive, net zero and equitable world.”

Jane Madgwick, Executive Director of the Global Commons Alliance:

"It's shocking to see how far into the danger zone we are for so many areas that we rely on for our safety and stability. At the same time, it's reassuring to see - in clear, quantified terms - the contours of a safe and just space that would allow people and planet to thrive. I am committed to making sure, that through the Global Commons Alliance, these Earth System Boundaries will inform and spark the urgent action necessary, across all sectors and scales."

Erin Billman, Executive Director of the Science Based Targets Network:

"The science is clear: we need urgent action right now across climate and nature because our Earth System is fundamentally interconnected. At the Science Based Targets Network we're helping companies with the critical "how" and the "what can we do about it" questions. We now have clear guidance that companies can use today to set integrated climate and nature targets - with an initial focus on freshwater and land - based on science, so that they can play their part in ensuring an equitable, net zero, nature positive future."

Appendix 2

FACT SHEET

Associated organisations

This science has been produced by the Earth Commission, the scientific cornerstone of the Global Commons Alliance. The Global Commons Alliance is a sponsored project of Rockefeller Philanthropy Advisors, supported by an Investor Collaborative consisting of: ClimateWorks Foundation, Generation Foundation, Gordon and Betty Moore Foundation, Global Environment Facility, MAVA Foundation, Oak Foundation, Porticus and the Tiina and Antti Herlin Foundation. The Earth Commission is hosted by Future Earth, the world's largest network of sustainability scientists.

The Global Commons Alliance is a growing coalition of scientists, philanthropists, businesses and innovators, inspiring new ideas and action to safeguard what's common and precious to us all: the global commons. Our mission is to mobilise citizens, companies, cities and countries to accelerate systems change, and become better guardians of the global commons. The GCA currently comprises over 70 partners, including the WEF, WBCSD, the Nature Conservancy and Capitals Coalition, and has five core components:

- The **Earth Commission** - an international team of leading natural and social scientists and five working groups of additional experts. The Commission is led by three distinguished professors: Johan Rockström, Joyeeta Gupta and Dahe Qin.
- The **Science Based Targets Network** - a collaboration of global non-profits translating the latest interdisciplinary science into targets for companies and cities.
- **Earth HQ** - democratising vital information and science, building public support for planetary stewardship, and tracking progress on the safe and just transition to a stable planet.
- The **Systems Change Lab** - leveraging data, analysis, expertise, and networks to learn from, track and accelerate the systems changes we need.
- The **Accountability Accelerator** - working with 100+ organisations to build a system of accountability that holds companies responsible for science-based targets and broader environmental performance.

Earth Commission Co-Chairs

Prof. Johan Rockstrom, co-author is Director of the Potsdam Institute for Climate Impact Research and Professor in Earth System Science at the University of Potsdam. Find out more about Prof. Rockstrom [here](#).

Prof. Joyeeta Gupta, co-author is full Professor of environment and development in the Global South at the Amsterdam Institute for Social Science Research of the University of Amsterdam and IHE Institute for Water Education. Find out more about Prof. Gupta [here](#).

Prof. Qin Dahe, co-author is Director of the Academic Committee of CAS, and Honorary Director of the State Key Laboratory of Cryospheric Science in Northwest Institute of Eco-Environment and Resources of CAS. Find out more about Prof. Qin [here](#).

Find out more about the other Earth Commissioners, and co-authors of the report [here](#).

Definition of key terms

Earth System. The Earth System is a set of interconnected physical, chemical and biological processes that keep the planet stable and operating. These include all living and non-living (abiotic) things at the surface of the Earth, bounded by outer space on the outside, and by the

inner Earth (with its own heat source) on the inside - for example land, ocean, atmosphere and poles, as well as systems such as the carbon, water, nitrogen and phosphorus cycles. Human activity is now the main driver of change to the Earth System and as that pressure increases, there is a risk that the processes, and the stability they provide, will start to break down.

- “forcings and feedbacks within the system, including biological processes, are as important to it functioning as external drivers” also “human activities are an integral part of system functioning.” ([Steffen et al., 2020](#))
- Today’s Earth System is a social-ecological system, that is, “a coupled system of humans and nature.” ([Berkes et al. 1998](#); [Liu et al. 2007](#))

Earth System Boundaries. Earth System Boundaries focus on quantitative and qualitative description of boundaries beyond which social-ecological systems may collapse and humans may be harmed. They go beyond planetary boundaries by both combining elements from local to global levels, and biophysical and social science knowledge domains. There are boundaries for climate, freshwater (surface and groundwater), fertilisers (nitrogen and phosphorus), biodiversity (managed land and intact nature) and aerosol pollutants, which are the most important interconnected systems upon which we and the planet’s stability depend. The Boundaries integrate two elements:

- **Safe boundaries** - within which the planet will remain stable (previously quantified in studies such as the Planetary Boundaries), and that we know can sustain human development.
- **Just boundaries** - within which the planet can sustain life i.e. all people can access basic resources and be protected from planetary harm.

For each Earth System, whichever is the most stringent of these is the Safe and Just Boundary.

Appendix 3

EXTERNAL DATA POINTS

Publicly available data for additional background and context - not endorsed or verified by Global Commons Alliance or the Earth Commission.

Nature/Biodiversity

- The global economy could face annual losses of \$2.7 trillion by 2030 if countries fail to invest more in protecting and restoring nature and ecological tipping points are reached. ([World Bank, 2021](#))
- \$44 trillion of economic value generation – over half the world’s total GDP – is moderately or highly dependent on nature and its services. Nature loss matters for

most businesses – through impacts on operations, supply chains, and markets.

([WEF, 2020](#))

- The World Bank has predicted that 51 countries will experience an overall fall in GDP of 10-20% by the end of the decade if vital ecosystems collapse. ([World Bank, 2021](#))

Climate

- As scientists predict the world is likely to enter an El Niño phase this year, a new study ([Science, May 2023](#)) finds that the average El Niño costs the global economy around \$3.4 trillion. This could rise to \$84 trillion by the end of the 21st century, as climate change continues to increase the frequency and duration of the El Niño weather pattern.
- Current climate policies are projected to cause 2.7C warming by 2100 - exposing up to a third of the world's population to dangerous levels of heat. ([Nature Sustainability, May 2023](#))
- Climate change is a threat to human well-being and planetary health (very high confidence). There is a rapidly closing window of opportunity to secure a liveable and sustainable future for all (very high confidence). ([IPCC AR6 Synthesis report, 2023](#))
- Risks and projected adverse impacts and related losses and damages from climate change escalate with every increment of global warming (very high confidence). Climatic and non-climatic risks will increasingly interact, creating compound and cascading risks that are more complex and difficult to manage (high confidence). ([IPCC AR6 Synthesis report, 2023](#))

Water

- About 380 billion m³ of water can be recovered from the annual volumes of wastewater produced. This type of water recovery is expected to reach 470 billion m³ by 2030 and 574 billion m³ by 2050. Beyond nutrient recovery and economic gains, there are critical environmental benefits, such as a reduction in eutrophication. ([UNESCO: UN World Water Development Report, 2021](#))
- Universal access to basic water and sanitation would result in \$18.5 billion in economic benefits each year from avoided deaths alone. Every \$1 invested in water

and sanitation provides a \$4 economic return from lower health costs, more productivity and fewer premature deaths. ([Water.org](#))

Air pollution

- Pollution remains responsible for approximately 9 million deaths per year, corresponding to one in six deaths worldwide. Despite ongoing efforts, little real progress against pollution can be identified overall, particularly in the low-income and middle-income countries where pollution is most severe. ([Lancet, 2022](#))
- Air pollution from burning fossil fuels like coal and diesel was responsible for about 1 in 5 deaths worldwide in 2018. ([Harvard, 2022](#))
- The cost of the health damage caused by air pollution amounts to \$8.1 trillion a year, equivalent to 6.1% of global GDP. ([World Bank, 2022](#))

Nutrients

- The overuse and waste of nitrogen across the UK agri-food chain would be worth approximately £2.3 billion each year to buy as fertiliser – equivalent to around half of all annual agricultural profits. ([WWF, 2022](#))

Appendix 4

CASE STUDIES & EXAMPLES

Publicly available examples for illustrative purposes - not endorsed or verified by Global Commons Alliance or the Earth Commission.

Regenerating Earth Systems

- A record number of river barriers were removed across Europe in 2022, boosting the health of rivers and the wildlife they support. ([Dam Removal Europe](#))
- As California recovers from its drought, farmers are intentionally flooding farmlands to restore underground aquifers. Much of this is being driven by the state's 2014 law to regulate groundwater, which mandates that by 2042, an equal amount of groundwater has to be returned to an aquifer as is withdrawn every year. ([CivilEats](#))
- On the Loess Plateau in north-central China, four million acres of the over-grazed, over-harvested lands have been transformed into productive farmland. ([Eos](#))

Challenges from breaching Earth System Boundaries

- In the **Netherlands**, heavy use of fertilisers have led to illegally high levels of ammonia and nitrogen oxide pollution, which is damaging waterways, land and biodiversity. To curb the damage, the Dutch government has introduced much debated limits on livestock, set targets for reducing pollution, and offered to buy out the most polluting farms. (Example coverage: [Politico](#))
- **Jakarta**, the capital of Indonesia, home to more than 10 million people, is currently sinking. Less than half the city's population has access to piped water, and illegal extraction of groundwater by both businesses and the public are depleting groundwater sources and resulting in significant subsidence. Other factors including soil depletion, deforestation and sea level rise are leaving the city's population at huge risk from flooding. If left unchecked, almost all of North Jakarta will be submerged by 2050. ([UNFCCC](#))
- In **Spain**, a large water transfer network has for many years brought water from the Tagus river to the Murcia region, enabling local farmers to grow a large proportion of the agricultural produce found in supermarkets across Europe. However, worsening drought in other parts of Spain has led to proposals from the Government to limit the amount of water being transferred, in order to support

farmers who are losing entire crops as a result of heatwaves in other areas.

(Example coverage: [France24](#))

Companies are already investing to have a positive impact on the Earth System, beyond a strict focus on climate and emissions reduction

- **Unilever** has developed a set of [Regenerative Agriculture Principles](#) to support the transformation of the way they use land and nature. For example, through the Iowa Soy Programme, Unilever has encouraged hundreds of farmers to plant cover crops in order to build healthier soils that can better absorb extreme rain falls or drought conditions, better hold nutrients in the soil, and have the potential to capture carbon.
- **Patagonia** supports a number of schemes to regenerate land and develop more sustainable agricultural practices. Through the [Remothering the Land](#) scheme, they draw on the practices and knowledge of Indigenous and Black farmers to support healthy soil, animals and people.
- Cosmetics group **Natura & Co** (owner of The Body Shop, Aesop and Avon Products, amongst others) works closely with local communities in the Amazon to develop [regenerative business models](#) that protect both biodiversity and the traditional and indigenous communities who keep the forests standing. As sustainable harvesting of ucuuba seeds (a key cosmetic ingredient) increased, deforestation of the tree dropped significantly, leading to the tree's removal from Brazil's endangered species list.
- **GSK** has launched a [sustainable procurement program](#) that requires all suppliers to take action on climate and nature - including improvements on emissions, energy, heat, transport, waste, water and biodiversity. As part of this GSK requires suppliers to achieve water neutrality in water stressed areas.
- [Seventeen global companies](#) are now preparing to submit science-based targets for nature (on freshwater and land) for validation, including **AB InBev, Alpro (part of Danone), Bel, Carrefour, Corbion, GSK, H&M Group, Hindustan Zinc Limited, Holcim Group, Kering, L'OCCITANE Group, LVMH, Nestlé, Neste Corporation, Suntory Holdings Limited, Tesco and UPM.**