

EARTH COMMISSION EXPLAINER BRIEF

FRESHWATER

PROTECTING FRESHWATER RESOURCES TO ENSURE A SAFE AND JUST FUTURE FOR ALL

Freshwater is essential to life on Earth. Human activities have contaminated and destabilised our water systems. A lack of freshwater leads to crop shortages, food and drink shortages, and economic decline. Adequate sanitation is threatened, leading to an increase in deadly water-borne illnesses. We must act now to ensure a safe and just future for humanity.

WHAT ARE EARTH SYSTEM BOUNDARIES?

The groundbreaking Earth System Boundaries (ESBs), identified by the Earth Commission, are scientifically quantified safe and just limits for climate, freshwater, biodiversity, nutrient cycles and aerosol pollutants.

They delineate a long-term *corridor* for humanity on a global scale – a *safe and just zone for people and planet*. By operating within these limits, we can maintain a stable and resilient planet and ensure access for everyone to the resources necessary for a dignified life.

Earth System Boundaries are hard limits. Even temporary overshooting of some of the boundaries can permanently damage the planet's critical systems, causing irreparable harm to life.

Earth System Boundaries can guide action towards a safe and just future for every human and the planetary web of life we rely on.

- *Safe* boundaries ensure stable and resilient conditions on Earth, within the Holocene range of variability, that we know can support human development.

- *Just* boundaries minimize human and nature's exposure to significant harm. In addition, the Earth Commission quantified minimum levels for access to resources for a dignified life and freedom from poverty for everyone.

WHAT DOES THE EARTH COMMISSION SAY ABOUT FRESHWATER?

We are taking colossal risks with our use of freshwater. Healthy freshwater environments sustain important fisheries and provide water for drinking, growing crops, and generating power. Their fringing vegetation also prevents erosion and provides natural protection from floods. The Earth Commission's findings are informed by flow-ecology research.

Flow alterations to freshwater systems occur through the damming of rivers, the direct extraction of water from rivers and / or lakes, and other water resource developments. Flow alteration is the primary cause of reductions in aquatic ecosystem health. It leads to reduced water quality, natural habitat and biodiversity losses. Dams also trap sediment and many river deltas are starved of their sediment replenishment that keeps them above sea level.

Much of the water we use for drinking, sanitation and agriculture comes from groundwater. Life would be impossible without it. Surface water flows are often dependent on groundwater. Extracting too much groundwater can affect the flow of rivers and streams. Overextraction puts agricultural production at great risk and can lead to irreversible land subsidence.

Although we have already breached the safe and just boundaries for freshwater, with long lasting impacts, the damage can be reversed: it is possible to move within the safe and just corridor for freshwater.

WHAT ARE THE KEY INSIGHTS WE CAN DRAW FROM THE EARTH SYSTEM BOUNDARIES FOR FRESHWATER?

- The Earth Commission has quantified safe and just Earth System Boundaries for Freshwater for both surface and groundwater (often referred to as ‘blue’ water).
- Groundwater, often from rainfall or snowmelt that has soaked into soil and rocks, exists deep below the Earth’s surface. Surface water includes any freshwater that flows into streams, lakes, and wetlands. These make up less than 1% of the world’s surface, and yet they host extraordinary biodiversity.
- *The ‘Safe’ boundary for surface water is to ensure we do not alter natural flows in river systems by more than 20%. The boundary is already significantly breached.*
- *The Safe and Just boundary for surface water globally, also requires ensuring flows in river systems in all local catchment areas are not altered by more than 20%. This boundary has been significantly breached. Natural water flows on over a third (34%) of all areas of land around the world have been altered - by dams, drainage or other kinds of human interventions - by more than 20%.*
- *The ‘Safe’ boundary for groundwater is for the annual extraction not to exceed the annual average replenishment for that specific regional groundwater source.*

- *The Safe and Just boundary for groundwater is the same measurement as the ‘Safe’ for groundwater because it protects groundwater dependent local ecosystems - like springs, wetlands and many farms - as well as rivers that depend on groundwater. This boundary has been significantly breached. Almost half (47%) of all areas of land containing river basins are beyond the boundary: i.e. more water is being extracted per year than is replenished naturally.*
- *Meeting the surface and groundwater ESBs will protect ecosystems and ecosystem services that healthy aquatic ecosystems provide.*

WHAT CAN YOU DO?

Freshwater systems are crucial for the well-being of people and the planet. Our resources are precious. We must stay within *safe and just boundaries for surface water and groundwater*. We must examine the impact of human activity on freshwater flow. We must protect freshwater ecosystems. *We can and must take action now.*

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CLIMATE

TACKLING THE CLIMATE EMERGENCY TO ENSURE A SAFE AND JUST FUTURE FOR ALL

Humans are taking huge risks with the future of civilisation on Earth. We are on the brink of destabilising the interconnected systems that ensure a stable and resilient planet – the prerequisites for human prosperity and equity for all. Without immediate action, the future for humanity will be neither safe nor just.

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WHAT DOES THE EARTH COMMISSION SAY ABOUT THE CLIMATE?

Greenhouse gas emissions from fossil fuel burning and agriculture are disrupting Earth's climate system. Earth is close to reaching dangerous climate tipping points. We have surpassed the safe and just threshold for climate, which puts us at high risk of significant harm. The Greenland and West Antarctic ice sheets are particularly at risk of tipping. The actions we take *now* will decide their - and by virtue our - future.

The safe and just Earth System Boundary for climate underscores the urgency of immediately phasing out fossil fuels and accelerating work from all directions to meet Paris Agreement Goals.

WHAT ARE THE KEY INSIGHTS WE CAN DRAW FROM THE CLIMATE ESB?

- Taking into account climate tipping points, recent climate variability and biosphere functioning, the Earth Commission identifies the 1.5°C temperature limit outlined in the Paris Agreement as the ‘safe’ boundary in terms of Earth system stability.
- If the world breaches 1.5°C, there is a high likelihood that multiple climate tipping points will be triggered, including melting of the Greenland ice sheet and loss of tropical coral reef systems.
- The Earth Commission’s justice analysis shows that people and ecosystems are already experiencing significant harm at the current 1.2°C of warming. *The ‘just’ boundary for climate is quantified as 1.0°C.*
- Because the safe *and* just Earth System boundary is set at the most stringent of the two, *the safe and just boundary for climate is therefore tightened to 1.0°C.*
- By setting the safe and just Earth System Boundary for climate at 1°C, the Commission is amplifying the injustice inherent in current world targets and the urgency to act to limit warming to as close to 1.0°C as possible.

WHAT EVIDENCE HAS INFORMED THE EARTH SYSTEM BOUNDARY FOR CLIMATE?

Earth Commissioners co-authored the recent analysis, [“Exceeding 1.5°C global warming could trigger multiple climate tipping points”](#), which shows there is a high likelihood that passing 1.5°C will trigger climate tipping points. The Earth System Boundary for climate takes into account a broad set of biophysical domains, incorporating justice considerations and the following:

- The temperature range of recent Earth history, from the comfortable stability of the Holocene, to the warmest “interglacial” periods within the Ice Ages.
- The impacts on biosphere functioning, such as weakened or reversed carbon sinks, and wildlife species losing their geographical range.
- The IPCC’s five “Reasons for Concern” in their latest Sixth Assessment Report, an assessment of risks induced by climate change.

- Earth Commission analysis of extreme heat and sea-level rise. We use two measures for extreme heat: mean annual temperatures above 29°C and wet bulb temperatures greater than or equal to 35°C for at least one day in a year, taking limited body temperature regulation due to humidity into account.

WHAT CAN YOU DO?

Damage from climate change is already happening to millions of people all over the world. All of us, but especially those in positions of power or decision making roles in finance, business and policy making, can and must evolve any current climate commitments and actions in line with the safe and just boundaries.

We can and must integrate justice, considering innovation and redistribution in order to meet basic needs for everyone. We can and must commit to working holistically across climate, biosphere, freshwater, nutrients (fertilisers) and aerosols.

Companies can start taking action now. A world economy that operates within safe and just Earth System Boundaries is one of the most important societal and business opportunities of our lifetime. Without immediate action, our future will not be safe. Nor will it be just. *We can and must take action now.*

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EARTH COMMISSION EXPLAINER BRIEF

AEROSOLS

STEMMING THE EFFECTS OF AEROSOLS TO ENSURE PLANETARY AND HUMAN HEALTH

As you take your next breath, consider what you and the rest of the world are breathing in. Air pollution – or aerosol concentration – comes from many different sources, both natural and from human activities, such as volcanic ash and traffic emissions. Particulate matter (one type of aerosol) is associated with respiratory illnesses and premature deaths. No level of air pollution can be called absolutely safe from a health perspective. *Our planet and its people are at risk from air pollution. We must act now to stop aerosol concentration from increasing.*

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WHAT DOES THE EARTH COMMISSION SAY ABOUT AEROSOLS?

Aerosols from natural sources dominate air pollution concentration in wild areas but anthropogenic (human made) sources are prevalent in areas where most people live. In the Northern hemisphere, there is more land mass and higher population, thus more polluting activities. If air pollution in the Northern hemisphere increases further, this could lead potentially to an imbalance of aerosol concentrations between the two hemispheres, which can potentially disrupt rain patterns, such as the monsoon system.

The Commission proposes a novel boundary for aerosols that links the Earth system to human systems to prevent millions of premature deaths annually and prevent altering of the monsoons.

WHAT ARE THE KEY INSIGHTS WE CAN DRAW FROM THE AEROSOLS ESB?

- The level of polluting aerosols in the atmosphere can have a disruptive effect on how the Earth system functions.
- A rising North/South hemispheric difference in aerosols can cause substantial adverse effects on regional rain patterns.
- The Earth Commission has set safe and just boundaries aimed to stem the negative effects of aerosols on both planetary health and human health.
- The safe and just boundary aims to avoid imbalances between Northern and Southern hemisphere aerosol loading to stabilise global rain patterns. The goal is *to prevent adverse health impacts causing millions of premature deaths annually and to prevent negative impacts from changed precipitation patterns.*

WHAT EVIDENCE HAS INFORMED THE EARTH SYSTEM BOUNDARY FOR AEROSOLS?

- The safe Earth System Boundary is defined by the interhemispheric difference in aerosol optical depth based on observational evidence from volcanic eruptions and modeling studies that show a rising North/South hemisphere difference in aerosol concentration can trigger regional-scale tipping points, which could lead to shifts in monsoonal patterns. This difference can cause substantial adverse effects on weather cycles that influence flooding and drought risk.
- *A more stringent just ESB is based on local air pollution standards since exposure to particulate matter (PM) poses significant harm to human health. The just boundary is set at 15 $\mu\text{g}/\text{m}^3$ mean annual exposure to $\text{PM}_{2.5}$ to avoid a high likelihood of significant harm from aerosols. This boundary is based on interim targets from WHO 2021 guidelines and EU and US EPA air quality standards.*

- *The just boundary aligns with the safe boundary at the global level. The global boundary is set on pollutants that could alter the monsoons, such as in West Africa and India. These pollutants could disrupt wet and dry seasons and rainfall in multiple regions.*

WHAT CAN YOU DO?

Although they are tiny and virtually unseen, aerosols have major impacts on our Earth system and health. While most aerosols are natural, 10% of aerosols found in our atmosphere are human made and can alter rainfall patterns, while also having led to millions of premature deaths from pollution related health issues.

Meeting basic needs for all while living within safe and just boundaries requires innovation and redistribution.

We must find ways to reduce fossil fuel use. We must eliminate deforestation, overgrazing and any activities that increase the rate at which aerosols enter the air. We must urge our lawmakers to follow clean air guidelines.

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NUTRIENTS

TACKLING THE CHALLENGES OF EXCESS - OR LACK OF - NUTRIENTS TO ENSURE A SAFE AND JUST FUTURE FOR ALL

Fertilisers are used in agriculture to provide extra nutrients, particularly nitrogen and phosphorus, for good crop yields. However, excess nutrients can degrade neighbouring ecosystems. This process is known as eutrophication, and it can push aquatic and land ecosystems past tipping points, beyond which biodiversity collapses. Conversely, in some parts of the world, there is not enough fertiliser to ensure a secure food supply. We must act now to ensure a safe and just future for humanity.

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WHAT DOES THE EARTH COMMISSION SAY ABOUT NUTRIENTS?

Nutrient Earth System Boundaries focus on the global nitrogen and phosphorus cycles, and the Earth Commission has calculated the maximum allowed agricultural surplus. The surplus is the input beyond what is used and removed by the crops. It is this surplus that drives environmental degradation. The surplus can be reduced to as close to zero as possible through increased fertiliser use efficiency.

Boundaries are set across different scales from local to global. This is because nutrient pollution is highly localised and context dependent, but the global aggregate is important too. Rich countries are overusing fertilisers, while low-income countries need more.

WHAT ARE THE KEY INSIGHTS WE CAN DRAW FROM THE EARTH SYSTEM BOUNDARIES FOR NUTRIENTS?

- Excess nutrients from fertiliser overuse drive pollution in soils, freshwater and the ocean, leading to biodiversity loss, toxic algal blooms, and water quality degradation. Excess fertiliser use also leads to significant emission of greenhouse gases and air-polluting aerosols.
- Damage to ecosystems affects the millions of people who depend on them for clean water. Eutrophication threatens the survival of fish and other aquatic life. There is a serious impact on human health.
- Huge amounts of nutrients are lost and wasted between field and plate, and most sewage ends up polluting land and water rather than being recycled as fertiliser.
- While rich countries mostly overuse fertilisers, many of the world's poorest don't have access to enough fertiliser, leaving them in food insecurity.
- Reserves of rock phosphate are limited, and requires often damaging mining.
- Synthetic nitrogen fertilisers also require climate-polluting natural gas and lots of energy to make, but could be replaced by "green ammonia".
- For the global Safe boundaries for nutrients, we've quantified maximum agricultural surpluses of 61 (35-84) teragrams of Nitrogen a year (TgN/yr - 1 teragram = 1 million tonnes) for Nitrogen and 4.5-9 TgP/yr for Phosphorus. Beyond these boundaries environmental degradation due to eutrophication becomes widespread.
- The global Just boundary for Phosphorus aligns with its Safe boundary because human harm here occurs due to eutrophication.
- For Nitrogen, the global Just boundary is set at 57 (34-74) TgN/yr. This is slightly more stringent than Safe because in a few places Nitrogen over-use pollutes drinking groundwater before environmental degradation occurs.

WHAT ARE THE SAFE AND JUST NUTRIENT BOUNDARIES BASED ON?

The Earth Commission has focused on agriculture when setting the boundaries, as this is the source of around 90% of human-driven

nutrient inputs to the Earth system. Human sewage is also accounted for, as is the potential for global redistribution of inputs.

- The *safe nutrient boundaries* are based on recent scientific papers identifying concentrations of nitrogen and phosphorus beyond which eutrophication and ecosystem degradation occurs.
- This was used to estimate the maximum nutrient surplus or input in each local area for nitrogen, and globally for phosphorus. For nitrogen, local surpluses were added together to estimate a global total surplus, and make a global safe nitrogen boundary.
- The *just nutrient boundaries* are based on the point at which widespread harm occurs to people. The safe boundary is also the just boundary for phosphorus, as harm begins with eutrophication.
- The safe and just ESB for nitrogen is more stringent because nitrogen pollutes drinking water first in some areas.

WHAT CAN YOU DO?

It is essential to tackle the challenges of excess nutrients or lack of nutrients in our soil. Innovation and redistribution are needed to provide a safe and just future for all. We need to examine the irreversible damage caused to ecosystems by excess nutrients, and the impacts of eutrophication. *We must stay within the safe and just boundaries for nitrogen and phosphorus. We can and must take action now.*

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BIOSPHERE

A THRIVING BIOSPHERE – “LIVING NATURE” – OR BIODIVERSITY IS CRUCIAL TO ENSURE A SAFE AND JUST FUTURE FOR ALL

Our biosphere includes people and all other living organisms that we directly or indirectly interact with. The biosphere is our common heritage that sustains human existence. How we treat this fragile sphere impacts our own wellbeing and ability to thrive.

Human activities such as deforestation, urban development and agricultural expansion threaten planetary health and global ecosystems, endangering the essential foundation that provides for our lives, wellbeing and economies.

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WHAT DOES THE EARTH COMMISSION SAY ABOUT BIODIVERSITY?

Unsustainable* practices such as logging and agricultural expansion are leading to irreversible changes in the biosphere. Excessive greenhouse gasses have changed weather patterns and temperature, which also significantly impact biodiversity and its contributions to human wellbeing. Intensive human use of land - both in urban regions and in agriculture - have left little space for local ecosystems to provide critical services for life, such as pollination, water quality regulation, pest and disease control, and the proven health and mental health benefits provided by access to nature.

Conservation efforts to preserve intact ecosystems, wilderness and protect species must be stepped up to also address the vital functional

role of biodiversity in working landscapes that support livelihoods, food and fuel production, such as cities, forest plantations and agricultural lands.

**The main direct drivers of biodiversity loss are: land use change, exploitation of natural resources, pollution and the spread of invasive species, and global warming.*

WHAT ARE THE KEY INSIGHTS WE CAN DRAW FROM THE EARTH SYSTEM BOUNDARIES FOR BIODIVERSITY?

- The Earth Commission has quantified safe and just Earth System Boundaries for Biodiversity for both natural ecosystems and working landscapes. *Natural ecosystems* refers to areas of largely intact nature with only limited human interference. *Working landscapes* refers to all human-dominated ecosystems, including urban areas, forest plantation and or agricultural land. Both are critical.
- The two Biodiversity boundaries complement each other and quantify how to maintain nature's benefits for all, conserve natural resources for future generations and maintain ecosystems in a healthy and sustainable state.
- The safe and just Earth System Boundaries for biodiversity - natural ecosystems and working landscapes - are the same, meaning that in this assessment there is no difference between the safe and just limit for each boundary.
- *The safe and just boundary quantified for natural ecosystems requires 50–60% of the global land surface be covered with nature that is largely intact* in order to ensure critical Earth system ecosystem services. including carbon and water cycles regulation and halting species extinction.
- *We are already outside of the safe and just boundary for natural ecosystems. 50–60% of natural ecosystems are needed for a safe and just planet. Today only 45–50% of Earth has natural ecosystems.*
- *The safe and just boundary quantified for working landscapes indicates that all working landscapes require at least 20–25% semi-natural habitat per square kilometer for critical local ecosystem services to be secured.*

This will help ensure access for all people to local ecosystem services.

- *We have already breached the safe and just boundary for working landscapes.* Globally, only about one-third of working landscapes have 20–25% semi-natural habitat per square kilometre that support human well being

WHAT CAN YOU DO?

Protecting the biosphere requires focussing beyond conservation and biodiversity health, and working to restore the benefits that biodiversity provides to human wellbeing. Steps in this direction can be achieved by reducing the drivers, or root causes, of biodiversity destruction, which requires innovation, redistribution and an end to overconsumption.

We must take urgent action to ensure we move within the *safe and just boundaries for both natural ecosystems and working landscapes*. This means conserving and restoring biodiversity and its benefits while ensuring just access for all people.

Efforts to halt and reverse nature loss in line with the Global Biodiversity Framework must be urgently prioritized and accelerated. *The safe and just boundary for natural ecosystems provides further scientific evidence for the need to halt and reverse nature loss as prescribed by the Kunming-Montreal Global Goals.*

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