

# Humanity deep in the danger zone of planetary boundaries: Study

September 17 2023, by Marlowe HOOD

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Water falling from a melting iceberg drifting along the Scoresby Sound Fjord, in Eastern Greenland.

Human activity and appetites have weakened Earth's resilience, pushing it far beyond the "safe operating space" that keeps the world livable for

most species, including our own, a landmark study said Wednesday.

Six of nine planetary boundaries—climate change, deforestation, [biodiversity loss](#), synthetic chemicals including plastics, freshwater depletion, and nitrogen use—are already deep in the red zone, an international team of 29 scientists reported.

Two of the remaining three—[ocean acidification](#) along with the concentration of particle pollution and dust in the atmosphere—are borderline, with only ozone depletion comfortably within safe bounds.

The planetary boundaries identify "the important processes that keep the Earth within the kind of the living conditions that prevailed over the last 10,000 years, the period when humanity and modern civilization developed", said lead author Katherine Richardson, a professor at the University of Copenhagen's Globe Institute.

The study is the second major update of the concept, first unveiled in 2009 when only [global warming](#), [extinction rates](#), and nitrogen had transgressed their limits.

"We are still moving in the wrong direction," said co-author Johan Rockstrom, director of the Potsdam Institute for Climate Impact Research (PIK) and a co-creator of the schema.

"And there's no indications that any of the boundaries"—except the [ozone layer](#), slowly on the mend since the chemicals destroying it were banned—"have started to bend in the right direction", he told journalists in a briefing.

"This means we are losing resilience, that we are putting the stability of the Earth system at risk."

The study quantifies boundaries for all nine interlocking facets of the Earth system.

# Humans breaching planet's ecological boundaries

Six out of nine boundaries for "safe operating space" breached, and two of the remaining three are borderline

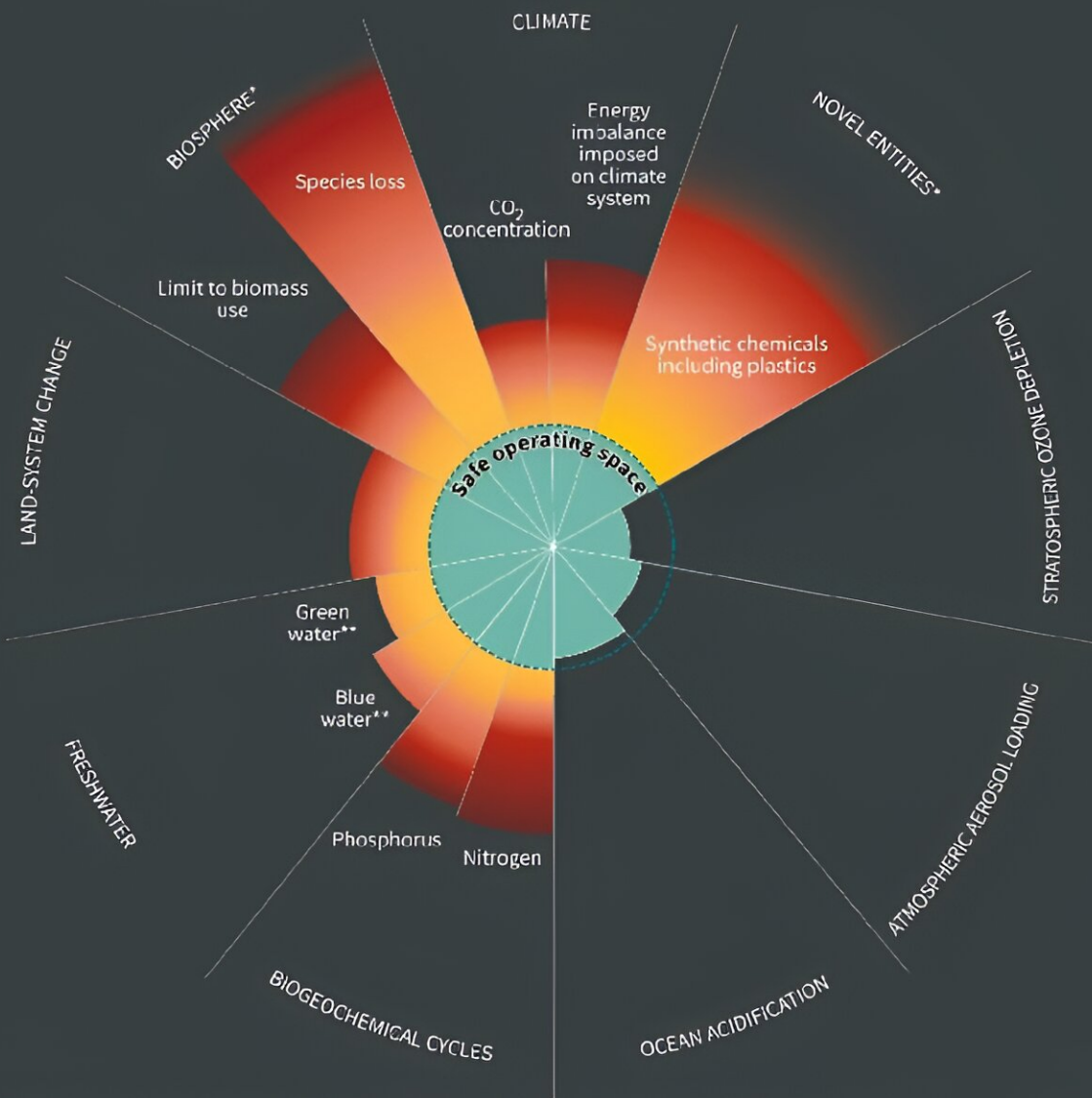
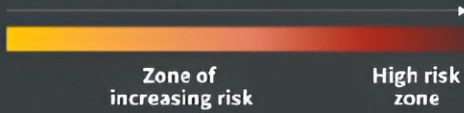
EARLY STUDY

In 2009, scientists identified **9 quantitative boundaries** crucial to Earth's stability and resilience

Breaching these boundaries means increased risk of large-scale abrupt or irreversible environmental changes

Boundaries updated in 2015 and 2023

Boundary transgressed



\*Blurred upper edges because either the increasing risk has not yet been quantified or known current value is uncertain

\*\*Green water is rain water stored in soil, evaporated, or transpired from plants. Blue water is water from rivers, lakes, ground

Source: Stockholm Resilience Centre



Humans breaching planet's ecological boundaries.

## Headed for disaster

For biodiversity, for example, if the rate at which species disappear is less than 10 times the average extinction rate over the last 10 million years, that is deemed acceptable.

In reality, however, extinctions are occurring at least 100 times faster than this so-called background rate, and 10 times faster than the planetary boundary limit.

For climate change, that threshold is keyed to the concentration of atmospheric CO<sub>2</sub>, which remained very close to 280 parts per million (ppm) for at least 10,000 years prior to the industrial revolution.

That concentration is today 417 ppm, far above the safe boundary of 350 ppm.

"On climate, we're still following a pathway that takes us unequivocally to disaster," said Rockstrom. "We're headed for 2.5C, 2.6C or 2.7C—a place we haven't seen for the past four million years."

"There's no evidence whatsoever that humans can survive in that environment," he added.

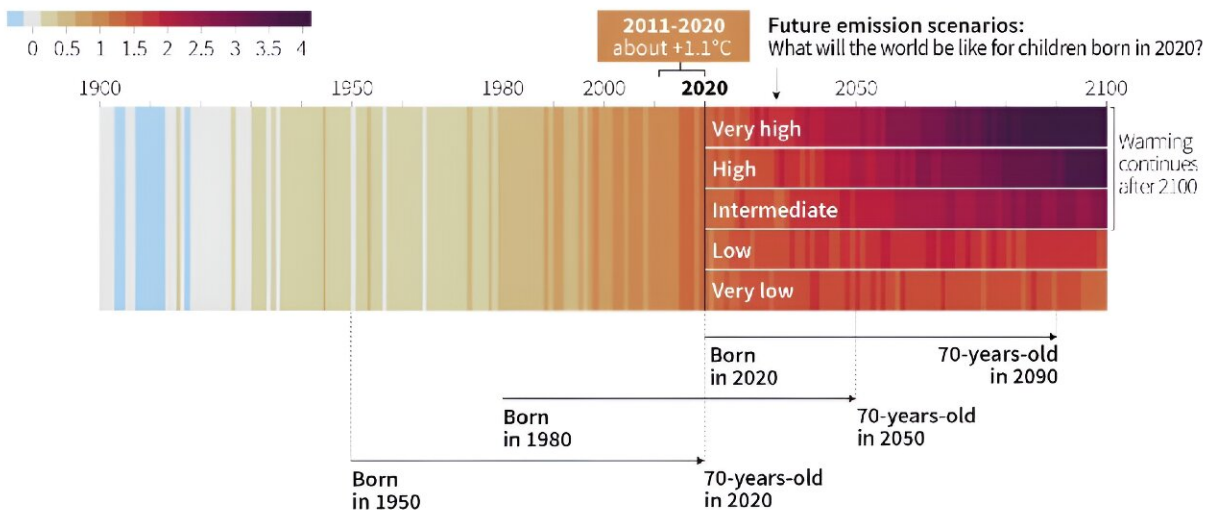
Thousands upon thousands of [chemical compounds](#) created by humans—from micro-plastics and pesticides to [nuclear waste](#) and drugs that have leached into the environment—were quantified for the first time in the new research, and found to exceed safe limits.

Likewise for the depletion of "green" and "blue" water, freshwater coming from soil and plants on the one hand, and from rivers and lakes on the other.

## Global rise in temperature determined by our current choices

Current hottest years will be among the coldest in 40 years

Temperature change at the Earth's surface compared to 1850-1900 levels (°C)



Source: IPCC, synthesis report of the AR6

Five scenarios of the evolution of the Earth's surface temperature.

## Setting limits

An important finding of the new update is that different boundaries feed off and amplify each other.

The study examines in particular the interaction between increasing CO<sub>2</sub> concentration and damage to the biosphere, especially forest loss, and

projects temperature increases when one or both increase.

It shows that even if humanity rapidly draws down [greenhouse gas emissions](#), unless destruction of carbon-absorbing forests is halted at the same time rising global temperatures could tip the planet onto a trajectory of additional warming that would be hard to stop.

"Next to [climate change](#), integrity of the biosphere is the second pillar for our planet," said co-author Wolfgang Lucht, head of Earth System Analysis at PIK.

"We are currently destabilizing this pillar by taking out too much biomass, destroying too much habitat, deforesting too much land."

All the boundaries can be brought back into the safe operating space, the study concluded.

"It's just a question of setting limits for the amount of waste we put into the open environment and the amount of living and non-living raw materials we take out," said Richardson.

Hotly debated at first, the [planetary boundaries](#) framework quickly became a pillar of Earth system science, with its influence extending today into the realm of policy and even business.

**More information:** Katherine Richardson et al, Earth beyond six of nine planetary boundaries, *Science Advances* (2023). [DOI: 10.1126/sciadv.adh2458](#)

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