News & views

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Figure 1 | The injustice of planetary change. Rockström *et al.*[3] have revised previously defined boundaries[1,2] for 'safe' planetary change to incorporate 'just' thresholds. They estimate that the just boundary for climate change was crossed when global warming reached 1 °C above pre-industrial levels, because tens of millions of people are now exposed to temperature extremes as a result – such as the people pictured in this camp in Dolow, Somalia, in May 2023, who have been displaced by drought, made more likely by climate change. The safe boundary is estimated to be 1.5 °C.

Sustainability

How to define unjust planetary change

Stephen Humphreys

Biophysical and sociopolitical factors have been integrated into a set of measures of planetary change that aim to pinpoint safe and just thresholds for all living things. The exercise is immensely ambitious and inevitably challenging. **See p.102**

Climate change is chief among several environmental pressures rendering Earth unsafe for many forms of life. A 2009 proposal put forward nine 'planetary boundaries' that define the safe space in which humanity can develop without jeopardizing the relative stability of the current Earth system[1,2]. But the impact of planetary-level change varies depending on the group or community affected. Now, members of the team that proposed the original boundaries supplement them with a set that aims to take these differences into account. On page 102, Rockström *et al.*[3] report a suite of eight 'safe and just Earth system boundaries' – limits whose transgression, they say, is not only unsafe for humanity and other living species, but also unjust.

The authors identify boundaries for the following Earth-system domains: climate; surface-water and groundwater integrity; the functional integrity of the biosphere; the extent of natural ecosystem area; the phosphorus and nitrogen cycles; and aerosol density (see Fig. 1 of the paper[3]). In five of the eight cases, the newly introduced 'just' limits coincide with a set of reassessed safe boundaries. The remaining three – pertaining to nitrogen, aerosols and climate – feature boundaries that are more constraining (in preventing harm) than the safe ones would be on their own. For example, Rockström *et al.* estimate that the just boundary for climate change was crossed when global warming

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reached 1 °C above pre-industrial levels, even though the safe boundary of 1.5 °C has not yet been exceeded. This is because, at 1 °C, tens of millions of people had already been exposed to temperature extremes (Fig. 1).

The 1 °C threshold is, then, one of seven 'safe and just' boundaries that the authors identify as having already been transgressed globally (with aerosols being the exception). They find that, in areas spanning 52% of the world's land surface, two or more of these boundaries have been crossed, and that these transgressions have affected 86% of the global population. In areas containing 28% of the world's people, four or more boundaries have been crossed.

The proposition of a safe operating space for humanity can be thought of in terms of homeostasis[4]: the proposed boundaries are tipping points whose transgression could send the planet into destabilizing paroxysms hostile to life. The earlier, influential 'planetary boundaries' suggestion has since been discussed by many scholars, including British economist Kate Raworth (ref. 5; see also go.nature.com/3mqnjwq) whose 'doughnut economics' provides a prescient framework for the updated boundaries. Raworth's model describes how social imperatives — such as the widely accepted goal of eradicating global poverty — impose constraints on already-limited planetary resources. The doughnut hole represents a lower bound to resource use (termed the 'access foundation' by Rockström and colleagues), and the edge of the doughnut is defined by the planetary boundaries. The space in between is conceived of as a 'corridor' within which humanity must ensure that resources are used justly as well as safely.

Rockström *et al.* have rejigged Raworth's boundaries and repositioned the just thresholds at the outside edge of the corridor. The thresholds no longer indicate merely the minimum resource use necessary to achieve just ends, but also maximum use to avoid harm, effectively recalibrating the safe boundaries. In practice, the authors seek to establish what they call 'Earth system justice' by converting sociopolitical ideas into biophysical quantities. The goal is to find a common language in which to express the fragility of Earth's system in the face of human impacts, as well as the point at which the resulting harm to human and non-human well-being, from the point of view of both environmental change and policies to address it, becomes unacceptable.

But translating between the natural and social sciences is not an easy task. To quantify harm, the authors have relied on new ideas of intergenerational, intragenerational and interspecies justice published this year in *Nature Sustainability*[6]. In each case, they calculated the just threshold as the point at which the impact of biophysical changes will cause 'significant harm', which is defined in a domain-specific way. The authors' conclusion is that safe Earth-system boundaries are themselves unsustainable in a world in which inequality is high and resources are unjustly distributed. The implications are immense.

The need for further research is potentially vast, and future work will certainly need to be interdisciplinary. For example, whereas homeostasis might be desirable for Earth as a biophysical system[1], it is much less obviously desirable for Earth's sociopolitical system: the definition of safe boundaries assumes that the status quo has inherent value, whereas most ideas of justice make no such assumption (given the huge variations in levels of human development across the world)[7,8]. The 'safe' boundaries and the 'just' ones are thus not merely in tension but potentially in outright contradiction. The world, after all, has been marked by high inequality and unjust resource distribution for a very long time: what, then, are the consequences of having now transgressed seven out of eight safe and just Earth-system boundaries?

At a minimum, the idea of just boundaries demands a reappraisal of long-standing debates about justice in the light of new circumstances — an immense task not undertaken by Rockström and colleagues. How can planetary-level effects be understood within the conventional framework of justice, given their varying impacts and distributional effects on different groups, which each have vastly different levels of responsibility for both causing and mitigating these effects[9]? The authors posit the need for policies that account for what they call distributive justice, but stop short of articulating what these policies might be. How can a good life for all be ensured within such tight constraints?

The sketch of interspecies justice is similarly minimal: human exceptionalism is rejected, but it is unclear what should stand in its place. Restating the obligation to conserve biodiversity is a start, but reducing the rate of species extermination hardly amounts to justice (see the discussion in ref. 6). The other thresholds (intergenerational and intragenerational) are subjects of a large and growing literature in which there is little agreement as to what they encompass or how they interact — factors that look very different when viewed locally or globally[9].

These are among the many questions opened up by Rockström and colleagues' study, and they will occupy scholars at the nexus of biophysical and sociopolitical research for some time to come. But although the work seems to raise more questions than it answers, it takes a crucial step towards bridging the divide between these research areas. In doing so, there is hope that it moves us closer to the realization of a truly safe and just Earth system.

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1. Rockström, J. *et al. Nature* **461**, 472–475 (2009).
2. Rockström, J. *et al. Ecol. Soc.* **14**, 32 (2009).
3. Rockström, J. *et al. Nature* **619**, 102–111 (2023).
4. Lenton, T. M., Dutreuil, S. & Latour, B. *Anthropocene Rev.* **7**, 248–272 (2020).
5. Raworth, K. *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist* (Random House, 2017).
6. Gupta, J. *et al. Nature Sustain.* https://doi.org/10.1038/s41893-023-01064-1 (2023).
7. Hickel, J. *Third World Q.* **40**, 18–35 (2019).
8. Hickel, J. *Lancet Planet. Health* **4**, e399–e404 (2020).
9. Humphreys, S. *Eur. J. Int. Law* **44**, 1061–1092 (2022).

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Medical research

Close to the finish of the polio endgame

Alan D. T. Barrett

Efforts to eradicate polio globally have been under way for more than 35 years. The development of modified versions of a vaccine in current use now makes eradication a real possibility. **See p.135**

Vaccination has been crucial for the control of certain infectious diseases. However, only two have so far been eradicated — the human disease smallpox and an animal infection called rinderpest. In both cases, the virus responsible was eradicated using a vaccination approach based on a 'weakened' version of the infectious virus (termed a live attenuated vaccine). On page 135, Yeh *et al.*[1] report their development of a live attenuated vaccine that might offer a way to eradicate poliomyelitis (polio).

Polio is a potentially life-threatening muscle-wasting disease, often associated

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