

Planetary Boundaries – Some Questions and Answers

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The answers given do not necessarily reflect the personal or institutional positions of all the authors.

New article:

Planetary boundaries: Guiding human development on a changing planet. Will Steffen, Katherine Richardson, Johan Rockström, Sarah E. Cornell, Ingo Fetzer, Elena M. Bennett, R. Biggs, Stephen R. Carpenter, Wim de Vries, Cynthia A. de Wit, Carl Folke, Dieter Gerten, Jens Heinke, Georgina M. Mace, Linn M. Persson, Veerabhadran Ramanathan, B. Reyers, Sverker Sörlin. *Science*, DOI: 10.1126/science.1259855.

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1. *Will the PB framework restrict development? Developing countries want to be able to develop without constraints. Will they not argue that wealthy nations have not been required to develop within constraints like PB, so why should developing nations face such constraints?*
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The planetary boundaries framework aims to specify precautionary biophysical boundaries within which humanity can thrive, but it does not indicate specific societal pathways for remaining and thriving within that safe space. There are likely to be many possible pathways that can deliver inclusive and sustainable development in that space. These pathways will be contested: different cultures, with their own needs, visions and values will view the costs, risks and benefits differently. And power is not evenly distributed among the world's social groups. The political challenges of future development and social justice will be great, because Earth's biophysical constraints are real, and not subject to political negotiation. The clear message from the new article is that continued inaction and policy implementation gaps on the planetary boundaries that are being transgressed now will reduce the options for fair and just pathways in future.

(See Leach, Raworth and Rockström, ch 6 in World Social Science Report 2013, <http://www.worldsocialscience.org/documents/wss-report-2013-part-1.pdf>)

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2. *Is the PB concept impractical for policymakers because it creates something else that must be negotiated at an international level? It will be impossible for all nations to agree on limits relating to nine boundaries given the difficulties regarding climate negotiations.*
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The planetary boundaries framework does not demand multinational negotiations and global agreements around nine static limits. It suggests a need for adaptive governance in the face of changing risks, and considerable scientific uncertainty. Addressing the boundaries effectively is very likely to require decision-makers to better recognize global environmental risks, and to respond at multiple scales. For instance, climate change is a global problem requiring international negotiations, but local responses are still needed, and choices being made at national or even community level have an important bearing on adaptation and mitigation measures.

Policies and institutional arrangements already exist at some level for all of the nine processes (although some have weak implementation capacity), and even for some of their interactions. This results in a complex and fragmented policy landscape. It deals poorly with emerging risks of thresholds that are intertwined at regional and global scales. As knowledge grows about these changing risks, it is likely that new institutional arrangements will be needed at the international level. This does not necessarily mean new formal global institutions – existing ones could be adjusted to address boundaries better. Some countries are currently exploring how the planetary boundaries framework can be applied as a way of improving policy coherence, and ensuring that

national efforts ‘fit’ the global sustainability challenges that the planetary boundaries concept highlights.

SRC’s Victor Galaz and colleagues have written several articles dealing with the governance challenges of planetary boundaries: [Current Opinion in Environmental Sustainability](#), [Ambio](#) and a [special issue in Ecological Economics](#).

3. *Is this too policy prescriptive? Are scientists overstepping their own boundaries and getting too close to policy? Or, worse still, positioning themselves above policy as the ultimate arbiter?*

Scientific evidence is recognized as an essential input to the policy process in many contexts. Global environmental change is just one. At the same time, the policy process is far from being a conversation just between policy-makers and scientists, and scientists do not unilaterally determine their position in that process!

The planetary boundaries are not actually policy prescriptive at all. The scientists propose precautionary boundaries, and leave the options for action open for policy-makers to explore and decide. However, the authors of the papers do indeed take a normative position about the sustainability of societies and the state of the Earth system – and they make that position clear.

It is important for scientists to be explicit about scientific findings that are relevant to policy, and for which there is strong evidence. The politicization of science is rightly a serious concern – not just for scientists and policy-makers, but also for the wider public. For most of the planetary boundaries, the scientists are actually *re-stating* messages that have been expressed very clearly within the expert communities of the individual boundaries. Many scientists in the global change research community view current escalating trends of unwanted environmental impacts with personal concern. For climate change and the loss of integrity of the biosphere, these trends are happening despite decades of research and policy targeting the problems. As human beings and members of society, scientists have an ethical responsibility to transmit scientific messages about urgent problems or high risks, not just to policy makers but to society at large.

4. *Do boundaries really exist at a global scale? Surely, some boundaries are local or regional? Why is it acceptable to aggregate them? The global N boundary is problematic because this boundary really only applies locally - African farmers need more N and could safely apply more N to the land, European farmers need to cut back. What is the value and credibility in scaling this to the global?*

The planetary boundaries approach is based on the concern that increased human perturbation of critical Earth System processes increases the risk of destabilizing the Earth System and changing the environmental framework within which human societies have developed. The Earth system is complex. It is typically described in terms of the interactions of land, oceans and ice-sheets, the atmosphere, and the biosphere. The physical, ecological and biogeochemical processes that link these components mean that changes in one component will ultimately play out across all the others. In this way, local changes can have important global consequences. In the new paper, we discuss these systemic behaviours in more depth. The new article takes the first step to bridge the global perspective of the original planetary boundaries work to the local contexts by characterizing large regional distributions. We also emphasise that climate change and the loss of biosphere integrity can be viewed as “core” boundaries, because they both are affected by and drive changes in all the others.

The spatial heterogeneity of the boundaries is very important, especially as the concept starts to be taken up in practical contexts. The heterogeneity has major implications for environmental justice – yes, African farms generally do need more N to be applied in order to increase food yields. However, recent analysis implies that even if fertilization is spatially optimized at a global scale, there is most likely still an exceedance of a planetary boundary for nitrogen application.

New lines of research are underway to improve models and observational data to help us understand the cross-scale dynamics of interactions between the biosphere, the non-living parts of the Earth system, and also the human drivers of change.

(See W. de Vries et al. (2013) Assessing planetary and regional nitrogen boundaries related to food security and adverse environmental impacts, *Current Opinion in Environmental Sustainability* 5, 392)

5. *If Earth remained within "Holocene-like" conditions, it would not support 7 billion people, let alone 10-12 billion. There is no going back to Holocene-like conditions. Nor would many want to. Wouldn't it be better to accept humans have irreversibly changed the Earth system for our own ends and will continue to, albeit a degree of caution is warranted?*

We do accept that humans have irreversibly changed the Earth system. This generation of humans is the first that has robust scientific predictive power about Earth's behaviour (IPCC AR5 summarises the impressive achievements worldwide). Models that incorporate multiple linked processes, historic and palaeodata compilations giving detailed global pictures of past environmental changes, and Earth observation that allows for real-time monitoring of present day changes. This evidence base is what motivates many scientists to call for a higher degree of caution than we have seen to date.

6. *How confident are you that science really understands tipping points and thresholds? The science here is very uncertain. Do you have confidence levels for these boundaries or zones of uncertainty, for example?*

The new paper seeks to apply quantified zones of uncertainty where these exist.

7. *Planetary boundaries has been compared with the 1970s' "Limits to Growth" and Malthusian scaremongering. Why is this different?*

The planetary boundaries concept is not a limits assessment like Malthus' Principle of Population or the Club of Rome Limits to Growth. Planetary boundaries are not concerned with bulk resource supply (although this may well need scientific attention), but instead seeks to determine the risks of destabilizing components in the Earth system arising from human-induced changes, triggering new feedbacks, crossing thresholds and unleashing tipping points in the Earth system. Most contemporary assessments of global change and impacts, such as the IPCC Assessment Reports, still fundamentally embed assumptions of monotonic linear trends over time including future predictions, using narrative scenarios to provide an indication of the scope of possible outcomes. In contrast, the planetary boundaries concept highlights the fact that Earth's physical (climatic), biogeochemical and ecological processes are more typically characterized by nonlinear responses and threshold behaviours.

The second key difference is that in the planetary boundaries concept, the critical thresholds are not based on human demands for resources. Earth's intrinsic dynamics set non-negotiable constraints on the human enterprise, so in the 'safe operating space' analysis, precautionary

global boundaries are set based on an assessment of the systemic thresholds in critical biophysical processes.

8. *How is it possible to have a boundary on "novel entities"? At the moment is it just too speculative to be credible?*

Several recent research articles have now addressed the globally systemic consequences of chemical pollution. Members of one of the world's leading ecotoxicology groups are part of the author team of the Steffen et al Science article, because their analysis has taken an explicitly Earth system perspective.

There is widespread evidence of accumulation of ecologically incompatible persistent chemical substances, complex pathways of exposure and potential 'cocktail effects' where mixtures of substances interact (e.g., UNEP Global Chemicals Outlook 2012).

But there are serious shortages of data about the production, use and environmental release of novel entities. Policy is constantly striving to catch up with innovations and new technologies that lead to new releases. Nevertheless, debates about how to deal more robustly with the Earth system risks of novel entities are actively underway in the chemical sector. For example, the measures in the EU REACH legislation for characterizing and dealing with highly dangerous substances (http://ec.europa.eu/enterprise/sectors/chemicals/reach/index_en.htm) are well aligned with the general traits of problematic novel entities for which precautionary boundaries are needed.

9. *How could you imagine the PB framework being used by nations, international organisation, businesses, cities, people?*

One way in which it is already being used is as a powerful communication tool about global sustainability, informing discussions in local communities, businesses, and many kinds of organization. The question of whether and how local actions "add up" to a desired shift to sustainability is vitally important, and the planetary boundaries provide some benchmarks for global sustainability. Combined with the idea of "social foundations", the Oxfam donut (Raworth 2012) extends from the biophysical boundaries to a description of a safe and just operating space for humanity. The planetary boundaries framework also serves as a reminder that multiple urgent environmental issues need to be held in mind at the same time, because they interact.

Countries can use the planetary boundaries framework to assess their national responsibility for environmental impacts, either within their territory or globally, in combination with footprinting approaches, say. Companies are exploring how to apply the framework with extended life-cycle analyses. LCA has long been criticized for being a relative measure. The planetary boundaries provides a structure for making more measures in LCA have an "absolute" basis.

The original papers have been cited hundreds of times, and prompted the publication of many other scientific publications. We now see rigorous exploration of planetary boundaries from many disciplinary perspectives. This multi-perspective scrutiny shows the strong demand in science and society for improved knowledge and quantification or characterization of complex systemic behaviour. It also starkly shows the limitations of current tools (models, Earth observation products, monitoring networks, and other data) developed within specific disciplinary or application contexts. We are continuing to work on advancing integrative methods and knowledge.

10. Why is it that climate change is not in the high-risk category if newspapers tell us all the time that climate change is the single most dangerous problem of our time and the window for action is swiftly closing?

The need to address anthropogenic climate change is urgent, and the risks and costs of inaction are increasing. So there is indeed strong consensus that there is very little scope for increasing CO₂ emissions much more in future without major impacts on society.

The planetary boundaries framework figure plots the current state of individual ‘control variables’ that have been selected from a perspective focused on Earth's biophysical dynamics. It does not plot the societal impact – or even a cross-cutting measure of the environmental impact – of these processes.

In other words, the red, yellow and green colours in the figure represent assessments of the risks of Earth system change, rather than direct and immediate risks to people. Anything outside the green ‘safe operating space’ represents a rising risk of crossing systemic thresholds.

The IPCC’s Fifth Assessment Report provides many visual representations of the impacts of climate change and the risks to people (especially Working Group II). It shows that in the last century, temperature has already changed substantially as a result of greenhouse gas emissions - http://www.climatechange2013.org/images/figures/WGI_AR5_Fig2-21.jpg.