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Identifying a Safe and Just Corridor for People and the Planet

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COMMENTARY

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Key Points:

- An integrated people and planet perspective is required to guide human development and use of the global commons
- We outline an approach to defining a safe and just corridor for a stable and resilient planet supporting human development
- A conceptual framework for linking safe and just Earth system targets is proposed

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Identifying a Safe and Just Corridor for People and the Planet

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Abstract Keeping the Earth system in a stable and resilient state, to safeguard Earth's life support systems while ensuring that Earth's benefits, risks, and related responsibilities are equitably shared, constitutes the grand challenge for human development in the Anthropocene. Here, we describe a framework that the recently formed Earth Commission will use to define and quantify target ranges for a "safe and just corridor" that meets these goals. Although "safe" and "just" Earth system targets are interrelated, we see safe as primarily referring to a stable Earth system and just targets as being associated with meeting human needs and reducing exposure to risks. To align safe and just dimensions, we propose to address the equity dimensions of each safe target for Earth system regulating systems and processes. The more stringent of the safe or just target ranges then defines the corridor. Identifying levers of social transformation aimed at meeting the safe and just targets and challenges associated with translating the corridor to actors at multiple scales present scope for future work.

Plain Language Summary For the first time in human history, we are now forced to consider the real risk of destabilizing our home, planet Earth. This is an existential risk, as we all need a planet that can sustain life and provide the basis for the well-being of all people. Here, we outline a conceptual framework for a global-scale "safe and just corridor" that delivers on these goals for people and the planet. The recently formed Earth Commission will use this framework to map key functions that regulate the state of the Earth system and provide life support to us humans, including processes such as biodiversity and nutrient cycling. It will also analyze the related justice components, for each of these Earth system

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target domains, in terms of how such ranges can be defined and how nature's contributions to people can be justly shared. Furthermore, social transformations that meet safe and just targets for all people and how the global-scale targets can be translated to targets for actors at other scales will be explored.

1. Introduction

Human development depends on safeguarding the stability of the planet (Steffen et al., 2018; Xu et al., 2020). Current human activities, especially of high consuming wealthy societies, are threatening the stability of Earth's life support systems and its capacity to support our future well-being in the Anthropocene (Steffen, Broadgate, et al., 2015). Simultaneously, key human development needs remain, including attaining the UN Sustainable Development Goals for all by 2030, and ensuring continued human well-being for a world population of possibly 10 billion people in 2050. Addressing these challenges requires a full integration of people's lives and the planet's stability.

Critical to achieving a full integration of ‘safe’ and ‘just’ is to scientifically assess a *safe and just corridor* for human development on Earth (Figure 1), which we define as follows:

> Safe Earth system targets are those where biophysical stability of the Earth system is maintained and enhanced over time, thereby safeguarding its functions and ability to support humans and all other living organisms.
>
> Just Earth system targets are those where nature's benefits, risks, and related responsibilities are equitably shared among all human beings in the world.
>
> A safe and just corridor for people and the planet is where safe and just Earth system target ranges overlap.

This *corridor* bounds pathways of future human development that are both safe and just over time. This safe and just corridor will provide high-level “outcome” goals and the context for companies, cities, governments, and other actors who want to take action by operationalizing scientifically guided sustainability in their ventures (Andersen et al., 2020). *Safe and just* also implies that the Earth's natural resources, such as budgets for carbon, nutrients, water, and land, are finite (defined by safety) and have to be shared between people and with nature.

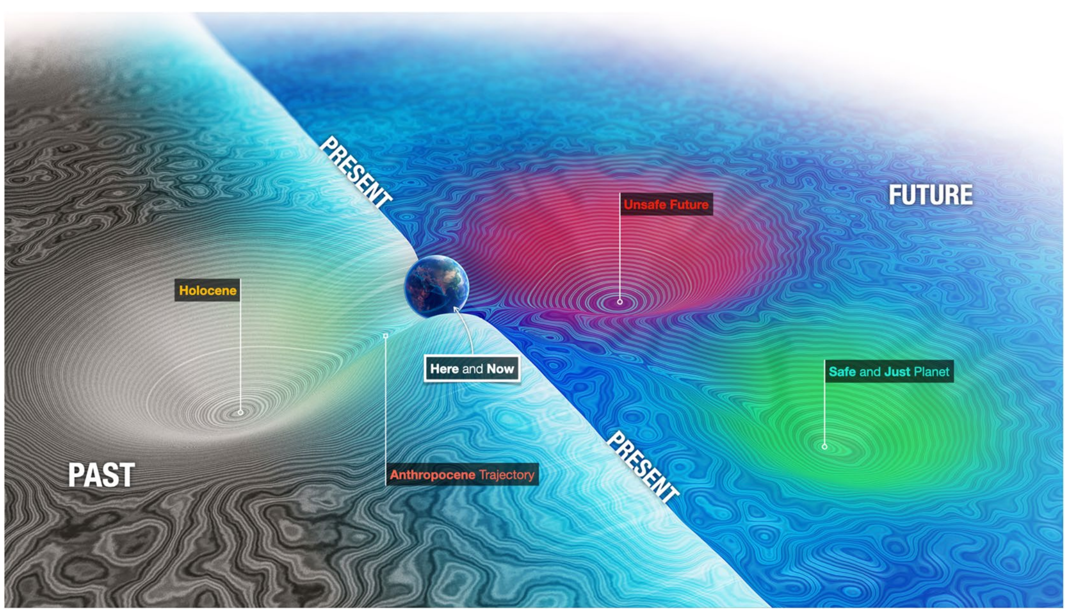

Figure 1. The challenge: To define, and navigate toward, a safe and just future for people and the planet.

We use *target* in the general sense of a measurable goal or objective, such as the target to limit climate change to "well below 2°C" (UNFCCC, 2015; Xu & Ramanathan, 2017), and *target range* to emphasize both (i) the uncertainty in science for both safe and just target setting, and (ii) our goal of synthesizing a range of safe and just conditions rather than prescribing any specific solution. We distinguish between *scientific* Earth system targets, targets at the global or near-global scale that are generated primarily by scientific inquiry but may be informed by societal judgments about risks (Pickering & Persson, 2020), and *science-based* targets, targets for actors that are aligned with scientific evidence but which may involve negotiations based on responsibility and feasibility (Andersen et al., 2020). Hence, practical downscaling of global scientific targets to specific science-based targets for different actors is beyond the scope of this study.

Previous frameworks, such as the planetary boundaries (Rockström et al., 2009) and donut economics (Raworth, 2018), have advanced our understanding of safe ceilings on human disruptions of the Earth system and just foundations for human access to natural resources. These frameworks, however, do not fully integrate safe and just, representing them with different dimensions (Earth system processes vs. social goals) and uncomparable variables. How biophysically "safe" targets can be achieved while also meeting goals for human well-being and justice is difficult to explore in such frameworks, for example, determining a safe *and just* allocation of land for food production. Furthermore, these prior frameworks explicitly incorporate neither sub-global scales (Dearing et al., 2014), interactions and feedbacks between variables (Lade et al., 2020), nor potential trade-offs between planetary targets and development and equity (Biermann & Kim, 2020; Pickering & Persson, 2020). An integrated framework is needed that aligns safe and just Earth system variables while also accounting for sub-global scales and interactions between Earth system processes. We now expand on the motivation, definition, and challenges associated with our proposal of an integrated safe and just corridor.

2. Defining Safe Earth System Targets

We are now experiencing rapid global changes due to human pressures in the Anthropocene, likely exceeding 'safe' levels in several dimensions. Species extinction rates are tens to hundreds of times higher than they were on average over the last 10 million years with an average of 68% decline in wild animal populations since just the 1970s (WWF, 2020); we have the highest atmospheric concentration of greenhouse gases in the last 3 million years, a geological period (the Quaternary) when global mean temperatures never exceeded 2°C of global warming above pre-industrial levels (Steffen et al., 2018); nine tipping elements that regulate the state of the Earth system have known tipping points that show worrying signs of destabilization (Lenton et al., 2019); and we have widespread pollution of air and water through our use of minerals, chemicals, and novel substances. The frequency of spillover of zoonotic diseases from animals to humans has increased (Karesh et al., 2012), most recently manifested in the COVID-19 pandemic, with zoonotic host diversity rising with human degradation of natural habitats (Gibb et al., 2020). There is an urgent need to define the safe targets for a stable Earth system, where risks of human-triggered irreversible changes and crossing of tipping points (Lenton et al., 2019) are avoided.

The scientific community has provided evidence-based targets to avoid dangerous climate change (Hoegh-Guldberg et al., 2018) or loss of biodiversity and its contributions to people (IPBES, 2019): for example, the "safe" climate target of holding global mean temperature rise well below 2°C (aiming at 1.5°C) above pre-industrial levels (UNFCCC, 2015). "Safe" targets are needed for the other vital processes and systems that regulate the state of the planet—including the appropriate allocation and configuration of land use, the health of the oceans, and the global cycling of nitrogen, phosphorus, and water that supports life.

Identifying safe ranges for these systems in isolation, for example as the planetary boundary framework has done (Rockström et al., 2009; Steffen, Richardson, et al., 2015), will not be enough to describe a safe corridor. The complex interactions and feedbacks among Earth system processes must be considered and can make a corridor much narrower (Lade et al., 2020). It is crucial to establish the key feedbacks regulating, or destabilizing, each safety variable, and how they interact on different timescales. To quantitatively assess and combine these feedbacks, an established but under-used approach of calculating and combining feedback "gain" factors (Lashof, 1989) can provide a useful framework. This framework needs to be fed with information on key relationships from running Earth system and integrated assessment models, including "off-line" model coupling (using the outputs of one as inputs to the other) to relate safety variables that are

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in separate models. Setting "safe" targets also need to account for timescales in the Earth system, for example, incorporating the change to future states of the Earth system committed by pressures now. And, the Earth system interactions may mean the safe corridor changes over time.

A useful reference Earth system state for defining safe targets is the Holocene, which began around 11,700 years ago. The Holocene's relatively stable climate, together with its configurations of biogeochemical cycling, and nature's contributions to people, have enabled extraordinary human development—from multiple independent origins of agriculture to increasingly integrated complex cities, economies, energy, agricultural, and communication systems. Only within a Holocene-like inter-glacial climate can we be certain that Earth can continue to support human development (Steffen et al., 2018). There is no evidence that billions of humans and complex societies can thrive in other known climates, such as the glacial ice age or Hothouse Earth (Steffen et al., 2018).

3. Integrating Justice in Earth System Targets

Human choices and actions could narrow or widen the safe and just corridor for human development. Considering the complex interactions, feedbacks, and non-linearities within and between societal activities and Earth system behavior, we need to advance beyond previous frameworks such as the "donut" (Raworth, 2018) to understand when "safe" and "just" ranges do and do not overlap.

First, an "unsafe" world is likely to increase inequality, so "safe" would seem a necessary pre-condition for "just"—but not always a sufficient one. A "safe" target from a biophysical perspective may not be adequate to prevent large-scale risks to humans in specific contexts. For example, there are large risks for many human populations even with a 1.5°C climate target (Hoegh-Guldberg et al., 2018).

Second, a key question is how biophysically "safe" targets can be achieved while also meeting goals for human well-being and justice. For example, meeting the social goals of Agenda 2030 without widespread transformations may lead to crossing safe targets for the biophysical state of the Earth system (Sachs et al., 2019). Achieving biophysical targets, such as 1.5°C for climate or increasing ecosystem protection, can undermine well-being, if, for example, bioenergy competes with food production, or protected areas undermine local livelihoods (Hasegawa et al., 2020).

Third, risks of exceeding safe and just targets are amplified for vulnerable people and can affect human health, displace people, and destabilize societies. At the same time, those most negatively impacted by environmental changes are often those who contribute the least environmental impact and have the lowest resilience and capacity to adapt (Gupta et al., 2020). A quarter of all death and disease is attributable to environmental causes (McClain et al., 2019). Extreme weather events disproportionately kill or harm the poor, women, the elderly, children, and indigenous people (McClain et al., 2019). Climate change may displace millions of people particularly in poorer parts of the world (Xu et al., 2020). The COVID-19 pandemic, linked in part to natural decline and greater human-wildlife contact (Gibb et al., 2020), has disproportionally affected the more vulnerable (Mesa Vieira et al., 2020). Their vulnerability is not innate but is often created by societal structures, attitudes, and governance systems that are unjust and do not prioritize well-being for all.

We propose that the stricter of the safe and just target ranges for each variable should define the safe and just corridor (Figure 2). Furthermore, we propose to identify a spread of safe and just targets corresponding to different physical risk tolerances and different understandings of environmental justice. For example, a climate target that is just for all humans could be stricter than a target that avoids most climate tipping points, which in turn could be stricter than a target that is just for only a minority of humans.

4. Levers of Transformation and Challenges of Translation

By identifying safe and just target ranges, the question arises: How can we achieve these targets and live within the corridor? Transforming toward a "just" world may be a pre-condition for being able to achieve a "safe" world. Leverage points to achieve such transformations are essential for governing our commons. They need to

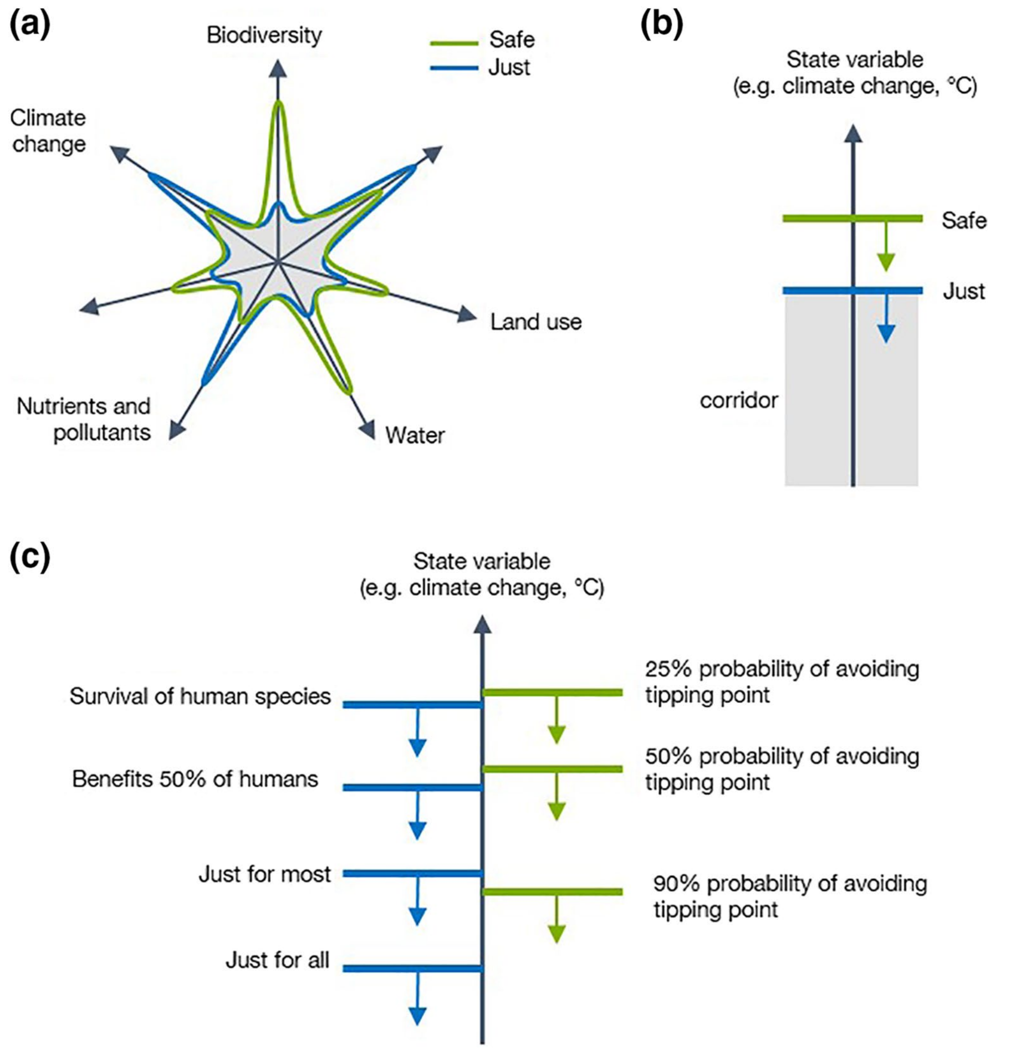

Figure 2. Integration of safe and just targets into the corridor. (a) For each biophysical variable, safe and just target ranges are identified. (b) We define the corridor (shaded) as the stricter of the safe and just ranges. In this example, the just range is stricter than the safe range. (c) We propose to identify a spread of safe and just target ranges corresponding to different risk tolerances. The variables and targets shown are strictly examples only.

be explored from equity, responsibility, and risk sharing, and participatory perspective to be effective (Ostrom et al., 1999) in the increasingly crowded, hyper-connected, turbulent, and high-risk world of the Anthropocene.

A key challenge is to identify systems that enable sharing of Earth's limited resources and nature's benefits to ensure human well-being in equitable ways. Agenda 2030 (UNGA, 2015) provides a global consensus on key justice principles of access and a starting point for an analysis of a safe and just corridor that aims to ensure that "no one will be left behind." But while it calls for reducing inequality, it has yet to set targets relating to how resources and risks should be shared. Although it calls for strengthening the means of implementation, it is unclear how such transformations will actually be leveraged. Learning the lessons regarding equity in sharing resources, rights, responsibilities, and risks is critical (Ensor & Hoddy, 2020). For example, the evolution of transboundary water law has led to the identification of key criteria for sharing water between nations (UNGA, 1997). Furthermore, the politics of who gets what, when, where, and how is often determined by those who are more powerful in the system. Rules of access and distribution then become locked-in and difficult to transform. Existing environmental assessments, with a few exceptions (IPBES, 2019), often do not make space to discuss the critical political science and international relations literature with respect to these issues.

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An independent synthesis of the broader social science literature is needed to map out: which response strategies are most effective in managing not just the symptoms of a problem but its underlying causes; which response strategies match the diversity and evolving nature of societies, cultures, economies, and technologies, and fulfill minimum criteria for ethics, transparency, trust, collaboration, recognition, and inclusive governance; the trade-offs and synergies between different goals and targets; and which actors and levers are most effective in enabling a transformation which shares the remaining Earth's resources in a just way, to ensure the continued functioning of Earth system processes for human development.

To put any of these ideas into practice requires the involvement of diverse actors across scales from the local to global (Ostrom et al., 1999). While cross-scale translation is necessary to inform decisions by such actors at sub-global scales, translation is complicated by the spatial heterogeneity of pressures and impacts (Biermann & Kim, 2020) and the value-laden (Biermann & Kalfagianni, 2020; Häyhä et al., 2016) and potentially iterative (Pickering & Persson, 2020) judgments involved in the allocation of these targets. Therefore, a synthesis of the challenges associated with translating global-scale Earth system targets to actors at other scales is needed.

5. Conclusions

We have introduced a conceptual framework for defining a safe and just corridor for human development in the Anthropocene. The Earth Commission (https://earthcommission.org/), convened by Future Earth, is an independent international scientific assessment initiative that will use this framework to conduct a scientific assessment of the safe and just corridor. As part of the Global Commons Alliance (https://globalcommonsalliance.org/), the Commission's theory of change includes providing results to the Science-Based Targets Network (SBTN), the Systems Change Lab, and Earth HQ, who jointly will mobilize actors to take appropriate measures. In particular, the Earth Commission's report will be used to underpin the development of science-based targets for business and cities by SBTN.

The Earth Commission now faces the challenge of identifying an integrated safe and just corridor for people on Earth, based on safe and just targets for all Earth system regulating systems and processes such as land, oceans, biodiversity, water, and nutrient cycles (nitrogen and phosphorous). We will then analyze levers of transformation and review methods and challenges associated with translating the safe and just corridor to actors across scales. We see this task as a much-needed advancement of integrated global sustainability research aimed at finding solutions for human development in the Anthropocene. We welcome scientific inputs based on new or existing work from scholars around the world to secure our future on Earth by defining a safe and just corridor and addressing this grand challenge on how to define scientific targets and levers of transformation (please submit through https://earthcommission.org/contribute/). Earth system and integrated assessment modeling groups are specifically sought to join in formulating the protocol and running a set of simulations for a new Earth and human system model inter-comparison project.

The present mutually reinforcing crises of climate change, biodiversity decline, and health problems illustrate that this frontier research is overdue. The COVID-19 pandemic shows that many jurisdictions are willing to prioritize health over monetary wealth, even if briefly, opening up transformation lessons for the future.

Data Availability Statement

Data were not used, nor created for this research.

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References

Andersen, I., Ishii, N., Brooks, T., Cummis, C., Fonseca, G., Hillers, A., et al. (2020). Defining "Science-based targets". *National Science Review*, nwaa186. https://doi.org/10.1093/nsr/nwaa186

Biermann, F., & Kalfagianni, A. (2020). Planetary justice: A research framework. *Earth System Governance*, *6*. 100049. https://doi.org/10.1016/j.esg.2020.100049

Biermann, F., & Kim, R. E. (2020). The boundaries of the planetary boundary framework: A critical appraisal of approaches to define a "safe operating space" for humanity. *Annual Review of Environment and Resources*, *45*, 497–521. https://doi.org/10.1146/annurev-environ-012320-080337

Dearing, J. A., Wang, R., Zhang, K., Dyke, J. G., Haberl, H., Hossain, M. S., et al. (2014). Safe and just operating spaces for regional social-ecological systems. *Global Environmental Change*, *28*, 227–238. https://doi.org/10.1016/j.gloenvcha.2014.06.012

10.1029/2020EF001866

Ensor, J., & Hoddy, E. (2020). Securing the social foundation: A rights-based approach to planetary boundaries. *Earth System Governance*. 100086.

Gibb, R., Redding, D. W., Chin, K. Q., Donnelly, C. A., Blackburn, T. M., Newbold, T., & Jones, K. E. (2020). Zoonotic host diversity increases in human-dominated ecosystems. *Nature*, *584*(7821), 398–402. https://doi.org/10.1038/s41586-020-2562-8

Gupta, J., Scholtens, J., Perch, L., Dankelman, I., Seager, J., Sánder, F., et al. (2020). Re-imagining the driver-pressure-state-impact-response framework from an equity and inclusive development perspective. *Sustainability Science*, *15*(2), 503–520. https://doi.org/10.1007/s11625-019-00708-6

Hasegawa, T., Sands, R. D., Brunelle, T., Cui, Y., Frank, S., Fujimori, S., & Popp, A. (2020). Food security under high bioenergy demand toward long-term climate goals. *Climatic Change*, *163*(3), 1587–1601. https://doi.org/10.1007/s10584-020-02838-8

Häyhä, T., Lucas, P. L., van Vuuren, D. P., Cornell, S. E., & Hoff, H. (2016). From Planetary Boundaries to national fair shares of the global safe operating space – How can the scales be bridged? *Global Environmental Change*, *40*, 60–72. https://doi.org/10.1016/j.gloenvcha.2016.06.008

Hoegh-Guldberg, O., Jacob, D., Bindi, M., Brown, S., Camilloni, I., Diedhiou, A., et al. (2018). Impacts of 1.5°C global warming on natural and human systems. In V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, & T. Waterfield (Eds.), Eds., *Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*.

IPBES. (2019). In S. Díaz, J. Settele, E. S. Brondízio, H. T. Ngo, M. Guèze, J. Agard, et al. (Eds.), *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. IPBES Secretariat.

Karesh, W. B., Dobson, A., Lloyd-Smith, J. O., Lubroth, J., Dixon, M. A., Bennett, M., et al. (2012). Ecology of zoonoses: Natural and unnatural histories. *The Lancet*, *380*(9857), 1936–1945. https://doi.org/10.1016/S0140-6736(12)61678-X

Lade, S. J., Steffen, W., de Vries, W., Carpenter, S. R., Donges, J. F., Gerten, D., et al. (2020). Human impacts on planetary boundaries amplified by Earth system interactions. *Nature Sustainability*, *3*(2), 119–128. https://doi.org/10.1038/s41893-019-0454-4

Lashof, D. A. (1989). The dynamic greenhouse: Feedback processes that may influence future concentrations of atmospheric trace gases and climatic change. *Climatic Change*, *14*, 213–242. https://doi.org/10.1007/bf00134964

Lenton, T. M., Rockström, J., Gaffney, O., Rahmstorf, S., Richardson, K., Steffen, W., & Schellnhuber, H. J. (2019). Climate tipping points – Too risky to bet against. *Nature*, *575*, 592–595. https://doi.org/10.1038/d41586-019-03595-0

McClain, S. N., McMullen, C. P., Abiodun, B. J., Armiento, G., Bailey, R., Balasubramanian, R., et al. (2019). Cross-cutting Issues. In U. N. Environment (Ed.), Ed., *Global environment outlook – GEO-6: Healthy planet, healthy people* (pp. 74–103). Cambridge University Press.

Mesa Vieira, C., Franco, O. H., Gómez Restrepo, C., & Abel, T. (2020). COVID-19: The forgotten priorities of the pandemic. *Maturitas*, *136*, 38–41. https://doi.org/10.1016/j.maturitas.2020.04.004

Ostrom, E., Burger, J., Field, C. B., Norgaard, R. B., & Policansky, D. (1999). Revisiting the commons: Local lessons, global challenges. *Science*, *284*, 278–282. https://doi.org/10.1126/science.284.5412.278

Pickering, J., & Persson, Å. (2020). Democratizing planetary boundaries: Experts, social values and deliberative risk evaluation in Earth system governance. *Journal of Environmental Policy and Planning*, *22*(1), 59–71. https://doi.org/10.1080/1523908x.2019.1661233

Raworth, K. (2018). *Donut economics: Seven ways to think like a 21st-century economist*. Random House Business.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., et al. (2009). A safe operating space for humanity. *Nature*, *461*(7263), 472–475. http://dx.doi.org/10.1038/461472a

Sachs, J. D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N., & Rockström, J. (2019). Six transformations to achieve the sustainable development goals. *Nature Sustainability*, *2*(9), 805–814. https://doi.org/10.1038/s41893-019-0352-9

Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O., & Ludwig, C. (2015). The trajectory of the Anthropocene: The great acceleration. *The Anthropocene Review*, *2*(1), 81–98. https://doi.org/10.1177/2053019614564785

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., et al. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, *347*(6223), 1259855. https://doi.org/10.1126/science.1259855

Steffen, W., Rockström, J., Richardson, K., Lenton, T. M., Folke, C., Liverman, D., et al. (2018). Trajectories of the Earth system in the anthropocene. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(33), 8252–8259. https://doi.org/10.1073/pnas.1810141115

UNFCCC. (2015). *Adoption of the Paris agreement*. FCCC/CP/2015/L.9/Rev1. Retrieved from https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

UNGA. (1997). *The United nations Convention on the Law of the non-navigable uses of international watercourses. (General Assembly resolution 51/229, annex, Official Records of the general Assembly. Fifty-first Session, Supplement No. 49 (A/51/49))*. Retrieved from https://legal.un.org/ilc/texts/instruments/english/conventions/8_3_1997.pdf

UNGA. (2015). *United nations general Assembly resolution 70/1, transforming our world: The 2030 Agenda for sustainable development*. A/RES/70/1 (21 October 2015)). Retrieved from http://undocs.org/A/RES/70/1

WWF (2020). In R. E. A. Almond, M. Grooten, & T. Petersen (Eds.), Eds., *Living planet report 2020 – Bending the curve of biodiversity loss*. WWF.

Xu, C., Kohler, T. A., Lenton, T. M., Svenning, J.-C., & Scheffer, M. (2020). Future of the human climate niche. *Proceedings of the National Academy of Sciences of the United States of America*, *117*, 11350. https://doi.org/10.1073/pnas.1910114117

Xu, Y., & Ramanathan, V. (2017). Well below 2°C: Mitigation strategies for avoiding dangerous to catastrophic climate changes. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(39), 10315–10323. https://doi.org/10.1073/pnas.1618481114

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