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Planetary Boundaries— Governing Emerging Risks and Opportunities

by **Victor Galaz, Aart de Zeeuw,
Hideaki Shiroyama, and Debbie Tripley**

NASA / Barry Wilmore

The Great Lakes and Central United States viewed from the International Space Station.

In Brief

The climate, ecosystems and species, ozone layer, acidity of the oceans, the flow of energy and elements through nature, landscape change, freshwater systems, aerosols, and toxins—these constitute the planetary boundaries within which humanity must find a safe way to live and prosper. These are thresholds that, if we cross them, we run the risk of rapid, non-linear, and irreversible changes to the environment, with severe consequences for human wellbeing. The concept of planetary boundaries, though recent, has already gained traction in scientific and in some policy circles, and is generating debate more broadly. Nevertheless, despite decades of talk on sustainable development, reform of international governance and institutions has not kept pace with the scale and urgency of the global environmental crisis. The notion of planetary boundaries can be seen as a way to frame governance reform. This discussion introduces key elements of governance in a world with boundaries: deep reform of international governance, such as the United Nations system and trade treaties; emerging ecological concepts and principles in international law; the role of economics for the biosphere; and, the need to integrate different kinds of knowledge—from the local to the global. The literature is rich with ideas for solutions and real-world experiences. One recent example from south-eastern Australia demonstrates innovative approaches to knowledge sharing and communication between scientists, urban planners, and local communities for sustainable development in a changing climate. Finally, there is need for a mobilizing narrative: a story grounded in the concept of planetary boundaries, uniting the solutions, and framed in such a way as to offer opportunities for learning, innovation, and creativity at all levels, in both the North and South. There are no simple solutions to what are complex problems involving politics and trade-offs. Ongoing debate and discussion—in academia, in policy circles, and in society at large—is healthy, but we should not allow debate about the precise nature of planetary boundaries to stymie progress. Exploring these issues and the interface between different fields is a challenging task, to be sure. Still, it is essential if the concept of planetary boundaries is to fulfill its potential as a guide for human action in the Anthropocene.

The notion of *planetary boundaries* attempts to define a safe operating space within which humanity can flourish. The boundaries relate to climate change, change in biosphere integrity (i.e. biodiversity loss and species extinction), stratospheric ozone depletion, ocean acidification, biogeochemical flows, land-system change, freshwater use, atmospheric aerosol loading, and the introduction of novel entities (such as radioactive materials and organic pollutants).¹

Recently, the original boundaries were updated, but the central message remains:² there are global environmental thresholds beyond which the risk of non-linear, abrupt, and irreversible changes rises substantially. Crossing the thresholds would have severe repercussions for human wellbeing. The idea of planetary boundaries is the subject of ongoing discussion and debate, both scholarly and socially, as it should be. Do thresholds in natural systems really exist? Does the framing with a focus on scarcity and global boundaries help or hinder action? Are boundaries a useful guide for human ingenuity and innovation for sustainable futures?³

Here, we build on existing debates, and identify five elements of governance mechanisms, or ‘solutions’ that, as yet, have received only modest attention.⁴ A word of caution: simple political or institutional solutions to such complex problems seldom exist. Instead, proposals for institutional reform are hard. They are always associated with political values and trade-offs, and hence need continuous public, scholarly, and political debate.⁵ And, as with any global sustainability issue, we need to bear in mind unresolved North–South issues and tensions.

The governance elements discussed here are related to issues around the need for:

- Deep institutional reform at the international level;

- The potential to tap into international law and legal principles;
- The importance of biosphere economics;
- The need for multi-scale knowledge integration;
- And, the need for a mobilizing narrative as a driver of transition.

Key Concepts

• There are planetary boundaries within which humanity must find a safe space to flourish. They constitute environmental thresholds that, if crossed, raise the risk of undoing much human progress.

• Despite decades of worldwide discussion on sustainable development, reform of international governance and institutions is outpaced by the rate of global environmental change.

• Key elements of governance reform to drive sustainable development are: deep institutional reform at the international level; key emerging concepts in international law and legal principles; the importance of biosphere economics; multi-scale knowledge integration; and, a mobilizing narrative as a driver of transition.

• Most likely to succeed is a narrative that, grounded in the concept of planetary boundaries, offers opportunities for learning, innovation, and creativity at all levels, in both the North and South.

• More sustainable outcomes at the local level can be achieved where scientists and planners work together with local communities to integrate global and local knowledge and establish better, ongoing dialogue.

We explore each of these elements briefly below. While none is straightforward and each has its implementation problems and trade-offs,^{6,7} we should not let this distract us from the urgent need to focus on solutions.

Shaking Up International Institutions

It is increasingly clear that incremental reforms of international institutions cannot keep up with the rate of environmental, social, and technological change which lead to the Anthropocene. In 2012, the Earth System Governance Project, an international network of social science scholars analyzing various aspects of environmental institutions and political decision-making, concluded that:

Incremental change—the main approach since the 1972 Stockholm Conference on the Human Environment—is no longer sufficient to bring about societal change at the level and with the speed needed to mitigate and adapt to Earth system transformation. Structural change is needed.⁸

In other words, actions to arrest the global environmental crisis have so far not matched the scale and urgency of the task.

Indeed, several authors have suggested more substantial global reforms.^{9,10} Biermann and colleagues, for instance, propose structural changes including (but not limited to): strengthening international environmental treaties; weaving environmental, social, and developmental values into global trade and investment regimes; upgrading the powers of the United Nations Environment Programme comparable to those of the World Health Organization or the International Labor Organization; and, better integration of sustainable development within the UN system itself.

These reforms aim to increase the legitimacy and accountability of international environmental policy-making and simultaneously increase coherence and help guide institutional interplay. The notion of planetary boundaries may serve as a guiding framework for these reforms. Reforms

such as these will surely be challenged, as they always have in the history of the UN and in global environmental governance in general. Barriers include insufficient multilateral commitment, knowledge gaps, and political gridlock, to mention a few.¹¹ This should not distract us from their importance, however.

Such reforms need to consider that environmental change is not only incremental, but also can unfold in abrupt ways with severe repercussions for human security. Globally networked risks pose severe global governance challenges and require not only structural changes, but also new flexible modes of collaboration at the international level. As the “food crisis” in 2008-2009, recurrent outbreaks of novel infectious diseases such as Ebola and Zika and, the possible cascading impacts of climate change on food security, financial stability, and human migration illustrate, the challenge to global resilience lies in maintaining both institutional predictability and flexibility. While this might sound like a difficult trade-off, recent studies show that a combination is possible, if embodied in globally spanning networks.¹² For example, the Commission for the Conservation of Antarctic Marine Living Resources has developed sophisticated information processing in collaboration with state and non-state actors in the last decade, leading to a much wanted reduction in illegal and unreported fishing.¹³ Adaptive and global collaborations between state and non-state actors such as these may provide space for much needed decentralized, bottom-up approaches involving multiple institutions and actors.

Tapping into International Law and Legal Principles

Overarching principles and norms in international law guide both state and non-state actors alike, and new norms have been proposed as a way



UN Photo / Mark Garten

Icebergs in Ilulissat Icefjord, Greenland, where ice sheets have been melting at an accelerating pace.

to address planetary boundaries. For example, Dutch environmental policy scholar Frank Biermann argues that overarching legal principles, as well as concepts of peremptory norms in international law (*ius cogens*, i.e. norms that no state may deviate from), could provide two good starting points.¹⁴ Similarly, Kim and Bosselmann argue there is a legal case for “a goal-oriented, purposive system of multilateral environmental agreements” based on a new legally binding international norm—a *Grundnorm*.¹⁵ The existing legal concept of *ecological integrity* could be used as a principle of customary international law and interpreted to include the science of planetary boundaries, as well as moral and ethical dimensions. In other words, a state would be required to ensure that their legal frameworks preserve ecological integrity, defined as within planetary boundary thresholds.

In a related idea, Higgins and colleagues propose making *ecocide* a crime, with states “legally bound to act before mass damage, destruction or ecosystem collapse occurs.”¹⁶ Other countries would have a duty of care to render aid where ecosystems

were at risk of collapse. This would entail, among other reforms, a new International Environmental Court.

The evolution of such norms might seem difficult, if not impossible considering the ever-existing risk of political gridlock and tangible conflicts of interest between states. However, as scholars of international relations, politics, and law have explored at length, norm changes with international level impacts can unfold in abrupt ways. Norms evolve through a life cycle as they emerge (often at the national level), cascade, and transgress a “tipping point” at which a critical mass of relevant state actors adopt the norm. This process can be facilitated by so-called “world historical events,” such as wars or major depressions, and is driven by “norm entrepreneurs” that link domestic and international politics in ways that contribute to the diffusion of the new norm. The prohibitions against certain kinds of weapons, the end of slavery, and the adoption of the Aarhus Convention in 1998 after the end of the Cold War exemplify abrupt changes in international norms. Whether the Paris Agreement in 2015, and the surprising



United Nations Photo

The leaders of COP21 celebrate the adoption of the Paris Agreement in December 2015.

explicit ambition to aim to limit the increase of climate change to 1.5°C above pre-industrial levels really will materialize, remains to be seen. At best however, this new ambitious target indicates a nascent international norm that puts climate stability and risk at the center of international discussions and national action.

Towards an Economics of the Biosphere

Planetary boundaries define a safe operating space; hence, crossing a boundary may lead to unacceptable costs. For a long time economics has ignored the type of instability and the possibility of multiple equilibria inherent in the notion of planetary boundaries. From the perspective of cost-benefit analyses, it means that shifting to another regime with another equilibrium and an unacceptable high loss of welfare should be avoided at almost all costs. In such a case, economics should not focus on adjustments towards the traditional, stable, narrow economic growth path, but on policies that take account of possible tipping points in the ecological system. A good example is climate

change. The planetary boundary can be characterized by an increase in global mean temperature of 2°C. This implies a budget of greenhouse gas emissions that the world as a whole has to respect. The issue is actually quite similar to the optimal extraction of an exhaustible resource. Economics provides tools for solving this type of problem, but it applies these tools mainly to resource economics, and has not yet made the switch to macroeconomics with planetary boundaries. Another important issue is the “tragedy of the commons” at this global scale. In the absence of an effective governing institution, the question is how the optimal use of the budget of greenhouse gas emissions is going to be implemented and respected. Economic research on stability of climate treaties with approaching catastrophes that could support the political processes of the COP meetings, such as the recent COP 21 in Paris, has just started.¹⁷

Interesting progress has been made in the last decade though, with important practical implications: the term *biosphere economics* denotes an emerging phase in economic research and policy

that takes tipping points and regime shifts in complex natural systems seriously.¹⁸ Biosphere economics builds on previously done important work, for example in developing alternative methods for measuring well-being,^{19,20} but highlights that the mere existence of a possible catastrophic threshold has important implications for policy making.²¹ Even if regime shifts are uncertain, a precautionary approach is required rather than optimization that ignores potential regime shifts. Planetary boundaries are kinds of *risk thresholds* with the potential to act as focal points and yield realistically optimal policies.^{22,23} Investments in resilience—that is diversity, flexibility, and learning—have costs, but become optimal when possible “tipping points” are taken into account. A good example is the management of the lobster fishery in Maine.²⁴ The fishery became very profitable when the lobster was turned into the only species in its functional group in the ecological system, but this increased the vulnerability of the system and the risk of collapse. In such a case, it is better to improve the resilience of the system at the expense of some fishery profits today, but this policy only results if potential tipping points are taken into account. Hence, focusing economic thinking on single metrics (such as GDP or efficiency) is not only simplistic, but also prone to failure, as it undermines resilience in the longer term. A dashboard of metrics that instead track planetary wellbeing, and that take threshold effects seriously, will prove much more useful as a guide for research and action.

Platforms to Link Global and Local Knowledge

The notion of planetary boundaries is quickly gaining ground in global environmental scientific assessments. A number of arenas for cross-disciplinary scientific synthesis have emerged in the last few decades, including the Millennium Ecosystem



NOAA Photo Library

Fisherman haul in a lobster trap in Boothbay Harbor, Maine. The lobster fishery in Maine provides a good example of possible “tipping points” in biosphere economics.

Assessment, the Intergovernmental Panel on Climate Change, and the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services. The new global scientific initiative Future Earth exists to create action-oriented science for the Anthropocene. These bodies are critical not only in standardizing global knowledge but also by constructing spaces for deliberation between science and society.²⁵

The policy impact of these initiatives cannot be taken for granted, as shown in decades of work on how scientific knowledge is used in policy-making and governance.^{26,27} An issue’s salience is seldom (if ever) enough to trigger international action, but must be combined with institutional mechanisms that enhance the credibility and legitimacy of information.

One of the most pressing questions arising in planetary boundary discussions centers on scale (so-called *downscaling*): are global thresholds and boundaries applicable to local, regional, or national levels? There is considerable debate on the usefulness of compressing multi-scale socio-ecological processes into simpler global metrics.^{28,29} A number of more practical and action-oriented attempts have come from academics and policy-makers.³⁰⁻³²

Downscaling is equally an institutional issue. The use of climate information and science in local settings is associated with vast challenges created by lack of information and data, capacity, and human and economic resources.³³ The situation is even more challenging in climate-vulnerable and fragile states where vital

monitoring infrastructure is missing and state capacities are weak or even non-existent³⁴ Moreover, whether useful and actionable planetary boundaries metrics and indicators can be developed at the local level remains to be seen.

A number of recent practical initiatives combine insights from global assessment programs with local knowledge in ways that are perceived as legitimate and transparent. Tengö and colleagues, for example, have studied multiple evidence-based approaches showing that local and indigenous knowledge systems, developed through long periods of experimentation, adaptation, and co-evolution, can provide valid and useful knowledge, as well as methods,

Continued on Page 52

Urban Sustainability: Joining the Dots Between Planning, Science, and Community

by **Barbara Norman**

By 2050, the global population will reach nearly ten billion, according to the United Nations.¹ The climatic impact of another three billion people, most of whom will be city-dwellers, is likely to prove substantial.² Cities are major contributors to global carbon emissions, accounting for 75 percent of world final energy use and 76 percent of carbon dioxide emissions (both numbers are median figures from the estimated range).^{3,4} More people, plus rising per capita consumption, will put already-strained natural systems, such as water and soil resources, under even more pressure. Even so, more sustainable cities and regions are possible, especially when scientists and land-use planners work with each other and with local communities. To be effective, such collaborations require sustained government support for partnerships, dialogue, and implementation. Frequently, however, there is little contact between the three groups, let alone cooperation.

Why? At first glance, their common interest seems obvious, but land-use planners, communities, and scientists tend to look at urban and regional futures quite differently. Planners focus on policy, scientists on Earth system dynamics, while communities are left to ‘make it happen’—to work with the policies and knowledge dealt to them. An integrated approach is needed, one that incorporates risk management and ongoing community engagement,⁵ as recognized in the UN’s 2015 Sustainable Development Goals.

Sustainability lessons can be learned from place-based projects that illustrate the challenges and opportunities of more connected policy and implementation. Nepal provides an example of policy at all levels of government—an important step forward—but also illustrates remaining challenges to on the ground implementation.

Dipak Bishwokarma and colleagues argue that the top-down funding model for less-developed countries, like Nepal, does not necessarily engender the local engagement critical to implementation.⁶ The internationally funded national plans, for instance, need to be better connected to the pioneering local ones. In essence, policy frameworks at all levels of government are a first step, but governance has to meaningfully integrate into the local and regional decision-making processes. The bottom-up mainstreaming approach and double linkage between national and local level adaptation plans is the foundation for sustainability of adaptation actions in less-developed countries.

A recent Australian coastal case study shows the importance of thinking creatively about communications and connections between scientists and communities. The South East Coastal Adaptation project took the innovative step of partnering scientists and planners with locals to explore infrastructure and other development issues in a changing climate.⁷ Three universities, together with seven local governments, worked with cultural practitioners over six months to explore new ways of more effectively engaging communities in the development of local solutions. This culminated in an innovative local art exhibition involving schools, town leaders, and researchers, which received national recognition. The study found that:

A prescriptive approach to settlement and infrastructure for coastal communities is less important than a decision-making process that is open, transparent, inclusive and adaptive, involving all levels of government and the community.⁸

The Nepali and Australian case studies highlight the importance of governance to effective local adaptation and sustainability planning. Support by higher levels of government, including funding, is crucial, as are arrangements that encourage collaboration. The case studies offer positive examples that emphasize local engagement. However, institutional barriers—ranging from conditions on foreign aid to local administrative arrangements—can still thwart progress.⁹

In this respect, the role of funding and development of boundary organizations can make the difference. Boundary organizations are bodies designed to bridge the gaps between different disciplines, and between policy, science, and communities. The Canberra Urban and Regional Futures (CURF) program, housed at the University of Canberra, is one example of a boundary organization. CURF is a platform for international collaboration on climate change and sustainability, health and well-being, settlements and infrastructure, and green growth.

Interdisciplinary, place-based case studies can be very useful in understanding systems and joining the dots so that solutions are fully realized. As cities and regions around the world grapple with a changing climate, scientists, planners, and communities will need to work with each other more closely. Sustainability and climate scientists, and land-use planners need to work more closely together to arrive at effective on-ground solutions. Cultural practitioners can play a vital role to ensure climate science is communicated effectively and communities are properly engaged. Crucial to successful cooperation is long-term public funding and governance arrangements that support transparency and the sharing of knowledge. **S**

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Continued from Page 50

theories, and practices for sustainable ecosystem management.³⁵ The importance of combining knowledge systems becomes apparent especially in community-based monitoring and information systems, or *bridging organizations*—those that connect actors across scales, and provide arenas for deliberation and learning.^{36,37} (See box.)

From these experiences emerge tangible examples of ways to down-scale planetary insights, sensitive to local issues. Such initiatives may also benefit from recent developments in communication and information technologies, improving early warnings, responses, and collaboration capacities.³⁸

The Need for a Mobilizing Narrative

Institutional reforms, legal principles, economic policies, and organizational innovation all play a role in Earth system governance. However, global transformation needs upward pressure from grassroots movements and sub-global deliberations, and the dynamics of transitions and transformations is the subject of considerable study,^{39,40} as are the processes by which societal

norms emerge, cascade, and reach a critical mass of relevant actors, finally becoming established.⁴¹

Such processes need a mobilizing narrative or framing;⁴² a story, which often has powerful implications for policy-making. Climate change, for example, can be seen as a technological challenge, the result of market failure, an issue of global distribution, or as the ecological limit to overconsumption. Each of these framings implies different policies and assignment of responsibilities and blame. Martin Hajer proposes another reframing of the issue—one focused on learning, innovation, and creativity:

Such a reassessment could involve combining green growth with the frame of the energetic society. Get citizens, farmers and businesses onboard, and develop a new, beckoning mindset that presents new opportunities, offers new openings, releases more energy and encourages the creativity that already exists in society to flourish.⁴³

Planetary boundaries need not imply a top-down narrative. A growing literature explores the possibility of using these boundaries as an engine

of socially and ecologically informed innovation.^{44,45} A kind of alternative framing can also be found in global initiatives, such as the work by the World Business Council for Sustainable Development.⁴⁶ It should be noted that many “planetary boundary” narratives are possible, ranging from techno-optimistic notions such as “Ecomodernism” and “Abundance,”^{47,48} to notions of changes in values and institutions to incorporate “Biosphere Stewardship,”⁴⁹ and anti-capitalistic critiques and ideas for fundamental global economic reform and redistribution of wealth.⁵⁰ It is difficult, if not impossible, to know how these different narratives will evolve or take root in complex social and political realities. On the contrary, we know very little about the conditions that make new problem framings materialize and replace older ones.

In addition, while the planetary boundaries framing might seem reasonable, it has nevertheless induced considerable debate between states with different development needs. As Frank Biermann notes, the notion of ‘thresholds’ embedded in the notion of a “safe operating space” also has unavoidable political dimensions.⁵¹ Vested interests will question the existence of these boundaries and advance

alternative counter-narratives.⁵² Actors can also differ in their risk adversity, or can interpret and value scientific uncertainties differently.

Ultimately, this means that a future oriented around planetary boundaries must be made attractive and meaningful to different actors in both the North and South. It must connect risks with opportunities, emphasize co-benefits, and explore abundance within a safe operating space.

Concluding Reflections

Discussions about possible governance reforms based on the notion of planetary boundaries are quickly gaining ground, and inducing much needed debates about the future of global environmental governance. We have touched on ideas around deep reform of global institutions, the potential to tap into law and legal principles, the importance of economics informed by biosphere realities, the importance of integrating knowledge across scales, and the need for a narrative that mobilizes people toward larger transitions. These are important starting points for more discussion and debate, not the final word. In fact, quick-fix solutions for governance and institutional problems this big and this important are impossible. Exploring these issues, and connecting risk with opportunities is a challenging task. It is essential, however, if the concept of planetary boundaries is to fulfill its potential as a guide for human action in the Anthropocene. **S**

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Belspo / Nevens / UN ISDR

The IPCC launches a special report in Brussels in 2012. The IPCC represents a cross-disciplinary body constructing a space for deliberation between science and society.

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Michael Studinger / NASA Goddard Space Flight Center

The moon remains in the morning sunlight over snow-covered peaks in northeastern Greenland. The photo was taken by scientists working on NASA's Operation IceBridge, a multi-year aerial survey of polar ice.

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