

Commentary

Patchwork Earth: navigating pathways to just, thriving, and sustainable futures

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Different regions, with different contexts and values, will follow different sustainability transformation pathways, giving rise to tensions and opportunities as the outcomes of regional pathways interact. To navigate these changes, we need a better understanding of how regional pathways interact to produce outcomes for people and nature.

Futures emerge from a patchwork of interacting pathways

Creating a sustainable and just future will require a major shift in how humans live in, and interact with, the Earth system and one another.¹ But how this shift could take place, the pathways it could follow, and its ultimate outcomes remain vague. Further, visions of sustainable futures differ widely. For example, some Millennium Ecosystem Assessment scenarios suggested that we should first concentrate on building strong, community-based stewardship to move toward a more sustainable future. Other scenarios implied that the pathway to sustainability could best be found through attempts to achieve a technologically driven, eco-efficient planet.² In fact, many different combinations of specific changes in diet, social values, trade policy, energy technology, and ecological practices are possible parts of a pathway to sustainability. And although these pathways (or others) or even combinations of intermingled visions and pathways might equally achieve the globally agreed-upon Sustainable Development Goals, each alternative future implies different outcomes for other social values, such as racial justice, gender relationships, and societal equitability, as well as different sets of winners and losers.

Envisioning desirable futures is a critical step toward creating such futures: we cannot work toward creating what we cannot even envision. Yet there is no “one-size-fits-all” approach; different regions and contexts, with different prioritizations of values, are likely to follow

different pathways that result in a variety of different outcomes. These pathways and outcomes in different regions can interact, creating both tensions and opportunities. Navigating these tensions, while respecting planetary limits and the need for context sensitivity, will be central to achieving a transformation to sustainability at broader global scales.

Many key aspects of regional sustainability shifts, and how they interact across locations, are likely to be novel, difficult to influence, or unpredictable.³ For example, climate change might make North Africa warmer and wetter, suppressing dust emissions and thereby reducing nutrient deposition in the Amazon, where these nutrients play an important role in primary productivity and the sequestration of carbon dioxide.⁴ Navigating these potential interconnections presents a major challenge for science and policy because it requires deep understanding of how context influences outcomes in a place, the interactions between places and across scales, and how they “add up” to outcomes for a global Earth system. This challenge necessitates integration of insights from across disciplines, the development of tools that enable people to govern for emergence, and an embrace of uncertainty and surprise rather than efforts to avoid it.

Historically, global changes, such as the spread of agriculture or the industrial revolution, resulted from an interacting patchwork of diverse social-ecological interactions that emerged from connections across geographic locations and networks⁵ (Figure 1). Even as globaliza-

tion has led to a more homogeneous world in many ways, the changes that result from global trade, technology, and financial markets are also shaped by specific local and regional contexts in ways that produce different outcomes in different places. For example, climate change and migration are experienced in different ways in London, England, versus in Dhaka, Bangladesh, because of differences in the histories, institutions, ecologies, and geographic context in these two places. London’s vulnerability is relatively low given that its residents have substantial mobility, whereas in Dhaka, many people are more exposed to sea-level rise and cyclones, compounded by low mobility. And although these places and their responses to global drivers are distinct, their intertwined histories of colonization, migration, and trade connect them to one another, ensuring that their dynamics are entangled in complex ways that are difficult to disentangle.

Four modes of pathway interaction

Given that many historical global changes resulted from diverse regional interactions, any global sustainability transition should also be expected to emerge from the interactions among a patchwork of geographically distinct, but interacting, pathways of change. Local changes can combine to produce global outcomes through aggregation, compensation, learning, or contagion (Figure 2). Aggregation happens when changes can be simply added together to a global total. For example, if many places shift away from fossil fuels, the

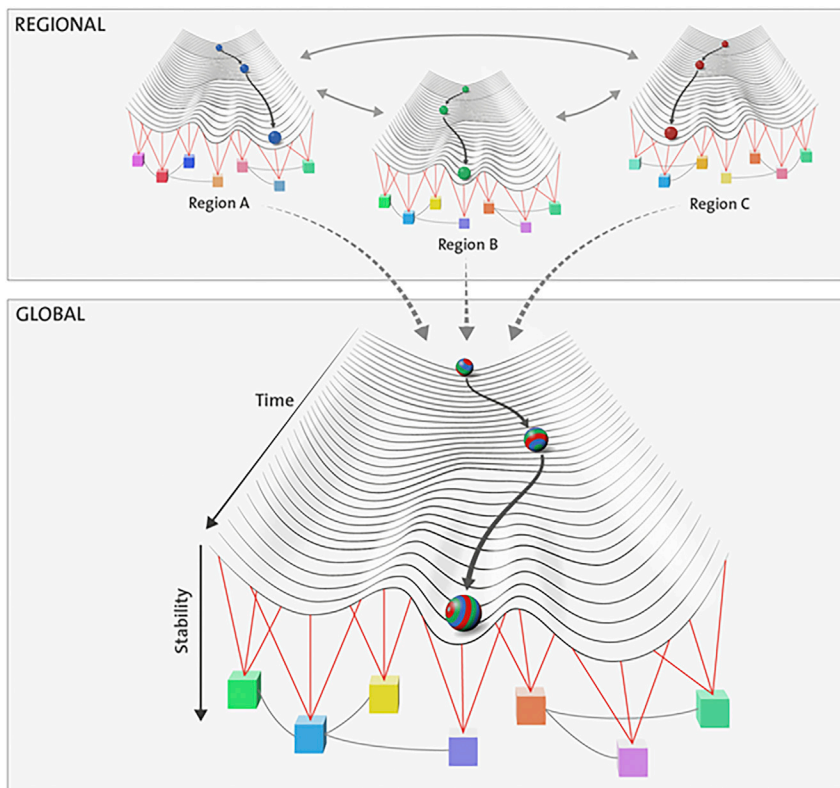


Figure 1. Pathways to sustainability are likely to differ between regions as a result of differences in histories, context, and values

Boxes below the landscape depict interacting factors that influence the landscape, changing its shape and making some outcomes more likely than others (though chance still plays a role in where the ball, which represents the state of the system, will travel). The interactions of those boxes are themselves influenced by the current state of the system in their own region and in other regions. A transition to sustainability at the global level will have to emerge from the combined effects of these regional pathways, including important potential interactions that could lead to unexpected effects. Based on figures in^{6,7}

total global reduction in fossil fuels is an aggregate of these local actions. Local actions can also produce a compensatory response elsewhere. For example, afforestation in Europe, North America, and Japan, alongside continued demand for wood products, contributed to the displacement of deforestation to the tropics.⁸ In such a case, the global impact of local actions could be less than the sum of local actions. Where local actions enable shared learning, they can catalyze action elsewhere, for example, by lowering the costs and enhancing the uptake of new technologies. In such cases, local actions will result in more change than expected from simple aggregation. Finally, local actions can be contagious; for example, both the Arab Spring and Black Lives Matter movements started in specific contexts and then spread to other places.

A global transition toward sustainability will thus emerge from the combined effects of aggregation, compensation, learning, and contagion of different actions in different places. Consequently, there are many unknowns and uncertainties regarding the form and outcomes of sustainability transitions at both regional and global scales. For example, at the start of the 21st century, solar energy was expected to be too expensive to compete with fossil fuels. However, in the 2000s, German energy policies subsidized and encouraged investment in solar power. This policy emerged for local reasons, but it grew the global market for solar power, accelerating the process of companies learning how make solar-power systems more cheaply. As we look back on this from 20 years later, global solar power has grown much more rapidly than expected and is now competitive

with fossil fuels.⁹ Although there are aspects that might be somewhat predictable, the history of societal transitions suggests that the most important effects are unknowable and will have to be made sense of and navigated as they arise.

Scenario planning to explore diverse futures pathways

Scenario development can be a useful tool for exploring a variety of possible, yet unknowable, futures by investigating potential pathways at variety of scales, as well as the factors and chance events that can influence how these pathways interact, resulting in different futures. The scenario-development process provides an opportunity for people to collectively discuss diverse futures, the pathways that might get us there, and uncertainties and chance events that might reshape those pathways. Global scenario-development efforts have played an important role in sustainability analysis, planning, and policy setting by enhancing researcher, policymaker, and funder understanding and by assisting in the exploration and consideration of uncertainties in the Earth system.¹⁰ For example, the Intergovernmental Panel on Climate Change uses scenarios to predict the greenhouse gas emissions associated with a variety of possible future developments, helping to clarify potential impacts of global agreements, and the Millennium Ecosystem Assessment scenarios explored a variety of contested philosophies about achieving a better future.

However, a focus on global policies and a desire to use well-established global models means that these futures have emphasized global and regional processes and commonalities at the expense of national and local dissimilarities, questions, and challenges.¹¹ Some historically important dynamics that are more difficult to model, such as the struggle for gender equality or the emergence of infectious disease, have been largely overlooked by global scenario-modeling efforts.¹² This global perspective often assumes that it will be possible to have globally coordinated and orchestrated actions that propel the Earth system toward one path or another or that global goal setting will suffice to produce change.¹³ Ultimately, these approaches to global scenario

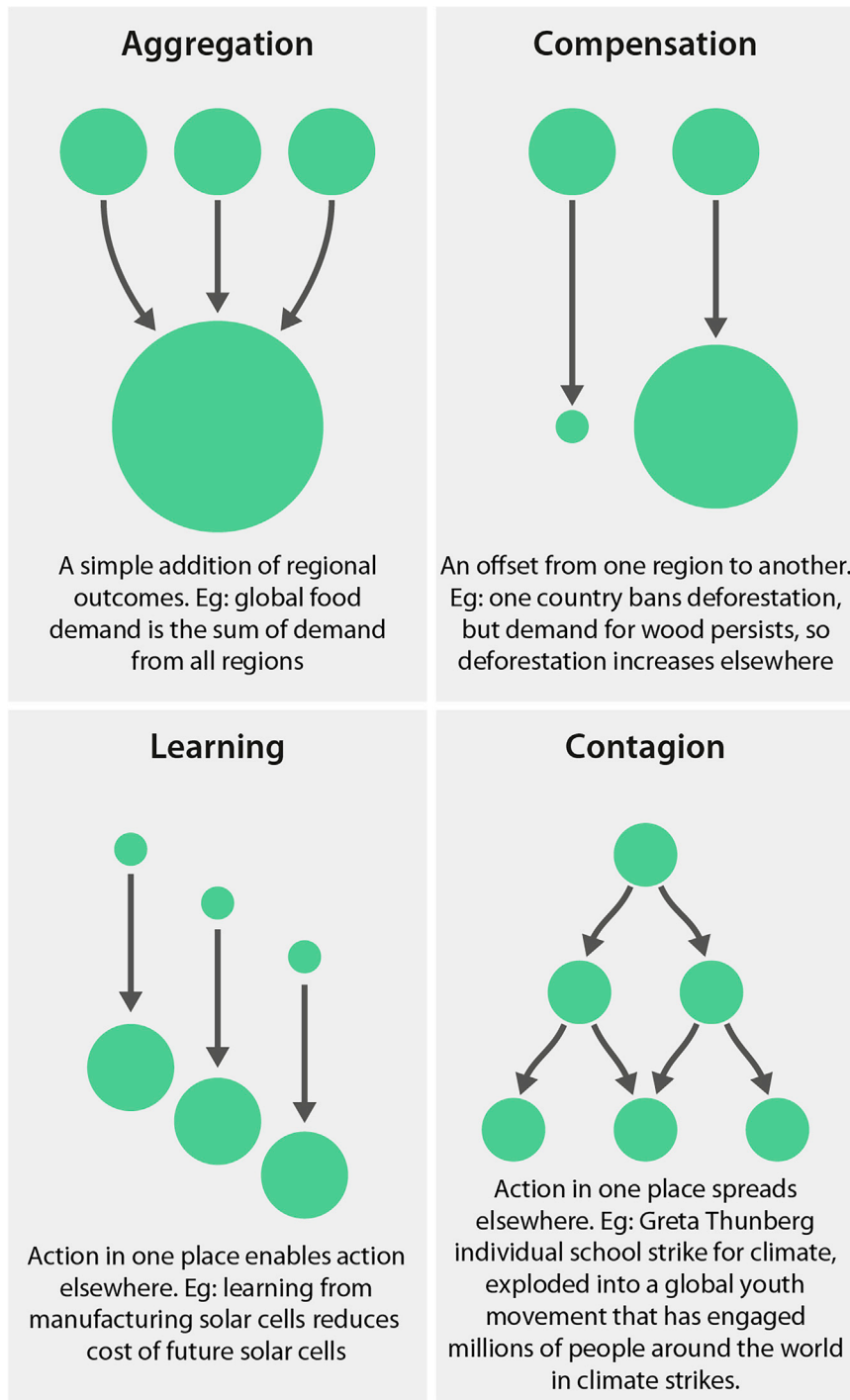


Figure 2. Four different ways that local changes combine to result in global outcomes: aggregation, compensation, learning, and contagion

building could hide as much as they reveal.

The world is complex and contradictory; a patchwork of local and regional contexts shapes the way drivers play out in different places, producing a world

where global forces create different on-the-ground outcomes. Thus, global futures that tell a single, globalized story of a transition in which the dynamics of Earth systems are products of global forces such as globalization, sustainability, or

populism might need to be complemented by other approaches if we are to better understand, navigate, and foster the complexity of real transitions. Addressing the challenge of navigating a complex emergent future with multiple possible constituent pathways and outcomes requires new approaches for exploring and creating the future that can complement existing global scenario-modeling work. We must broaden our dominant global planning and forecasting approaches to include a plurality of desirable futures, a greater variety of pathways toward achieving those visions, and greater rigor and depth in our treatment of the outcomes of interactions among places and people. This will require participation and sense making by a wide range of actors involved in on-the-ground initiatives and policymaking toward better futures at all scales.

One attempt to engage with multi-scale complexity in scenario development is the Seeds of Good Anthropocenes project (<https://goodanthropocenes.net/>).² In the scenario-development method pioneered in this project, participants develop radical positive visions of the future on the basis of existing real-world “seeds” of a better future.¹⁴ Such seeds are existing innovations that aim to address social-ecological challenges, but they are not yet mainstream, such as urban community gardening initiatives or blockchain technology. Scenario development begins with sets of seeds that are different in their worldviews, problematization of the current state of the world, and approaches to achieving a better future. Participants then imagine the outcomes if these seeds were fully mature and mainstream, including exploring how different seeds would interact (synergistically and in conflict), to develop visions of the future that are positive, realistic, and pluralistic. This approach combines the Mānoa method of amplifying “weak signals” to generate scenarios¹⁵ and the Three Horizons Framework of considering transformational change,¹⁶ both of which are widely used in local scenario practice but are not typically applied to exploring global environmental futures. This scenario method has now been used in a variety of settings around the world,^{17,18} primarily at regional scales, to develop scenarios that are more pluralistic, diverse, and radically alternative than mainstream

scenarios.¹⁹ Currently the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services is using some of these approaches to develop a pluralistic cross-scale approach to global nature that articulates possible pathways to alternative sustainable futures.²⁰

Navigating toward more desirable futures

Working in government, civil society, and business are change makers who are passionate about creating better futures. Enabling people who inhabit different places and embrace different values to imagine ways their efforts to build better futures could help one another requires new ways of thinking about the future. Pathways to sustainable futures that more fully account for regional complexity and emergent dynamics provide space for these actors to imagine how they might act to help create better futures and can foster action toward those futures. To increase capacity to navigate toward a more sustainable future, we propose that science and policy should do a better job of envisioning diverse desirable futures, nurturing seeds of sustainability, and navigating emerging pathways.

1. Envision diverse desirable futures: given the scale of the sustainability challenges we face and the diversity of values held by people around the world, we need greater plurality in our understanding of what might constitute a desirable future for different people in different places and a better understanding of the potential conflicts, opportunities, trade-offs, and synergies between pursuing different visions in different places. Broadening the participants engaged in processes to imagine possible futures can expand the perspectives considered and enlarge the range of envisioned futures. We must also consider the interactions among different places and how those interactions might affect the trajectories being pursued by different regions.
2. Nurture seeds of sustainability: transformative change requires that new structures and organizations supplant existing ones that

are no longer working. We need to nurture the growth of seeds of desirable futures and deconstruct the institutions and organizations that impede their growth. Developing policies to enable these changes requires research on transformative change to evaluate, support, and connect a diverse array of sustainability initiatives. Considering integrated futures and interactions across seeds and possible futures is key; solutions to one problem that create new problems or make other problems worse need to be avoided.

3. Navigate emerging pathways together: navigating emergent pathways demands ongoing processes of knowledge co-production, reflection, and action. Rather than scientists figuring out how things work and then policymakers acting on that knowledge, the world needs scientists, policymakers, and practitioners to work together in ongoing processes of adaptive action, learning, and reflection to identify and engage with unexpected surprises, conflicts, and trade-offs as they emerge. Enabling these processes requires investment in new organizations to bridge knowledge and practice, new policy approaches that account for complexity, and better support for scientists to engage in ongoing policy processes.

The complexity of the world is both a challenge for envisioning how to enable transformation to a more sustainable and just future and a source of hope. The world is changing in ways that are both predictable and surprising. Recent surprises, such as the emergence and spread of coronavirus disease 2019 (COVID-19), and people's responses to it are an excellent example. Complexity means that control is imperfect and surprises are to be expected, which implies that it might be difficult to describe and navigate a precise path to a sustainable future, as well as that oppressive systems can fall apart and unexpected successes can grow. Any "global" transition to sustainability will almost certainly be made up of the emergent outcomes of multiple pathways in different places that don't

always align and involve trade-offs and conflicts between different regions and places, but it will also present opportunities. Incorporating more of the diversity and complexity of the world in our thinking about the future and better understanding the opportunities and tensions that could arise can help increase our collective capacity to transform toward a more sustainable and just world for all.

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