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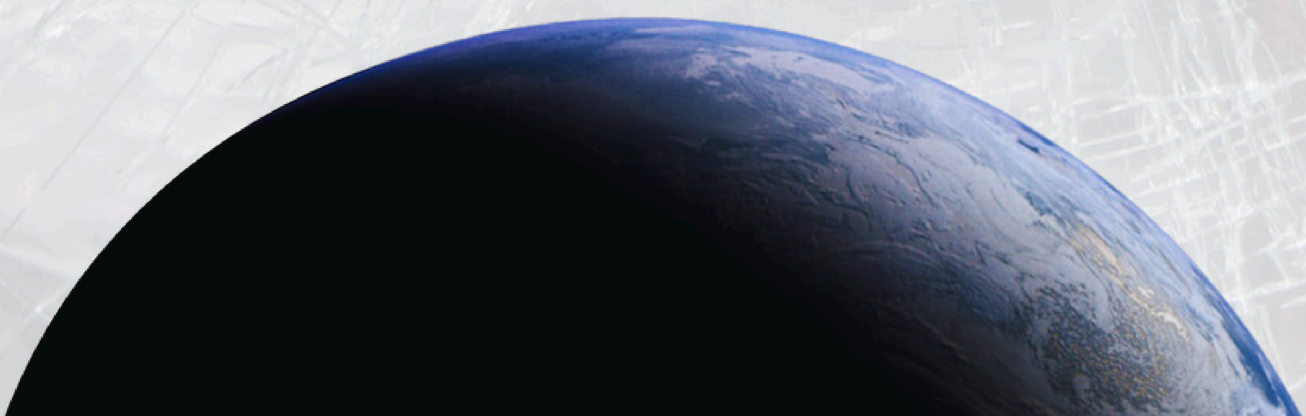
Interventions for Rapid Global Change

Positive Pathways through Polycrisis

Michael Lawrence and Megan Shipman

July 2024



Introduction

The emerging field of polycrisis analysis offers novel insights on the complex and systemic nature of the world's intersecting problems. Its findings are generally bleak. The more we investigate, the more densely interconnected, mutually reinforcing, and structurally entrenched our problems seem to be. Knowledge about their depth and complexity is crucial for effective action, but insufficient.

If polycrisis analysis ends there, it risks becoming just another exercise in "doom-casting," or worse, an excuse for fatalistic complacency. Fortunately, it has more to offer. As a crucial next step, the field must translate its understanding of polycrises into actionable strategies to alleviate them. This Report explores how to do so. It suggests ways in which polycrisis analysis can build on existing approaches to systemic change to help chart positive pathways to better futures.

The first section considers the sorts of systems changes required to avoid, mitigate, and navigate through polycrisis, highlighting the dual nature of crisis as harmful disaster and opportunity for transformation. The second section examines the progression between three prominent approaches to understanding systems change: leverage points, tipping points, and multi-systemic stability landscapes. Each approach improves upon shortcomings of the others but faces its own limitations for addressing polycrisis. Building on these approaches, the final section explains how underused tools like Cross-Impact Balance (CIB) analysis can advance the search for *positive pathways* by identifying alternative possible equilibria in global systems.

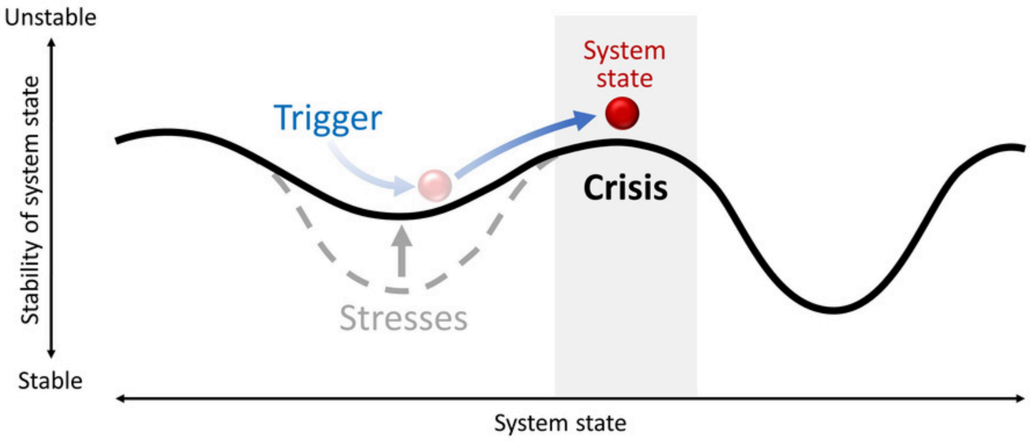
1. Preventing systemic crises or inducing transformative change?

What does it mean to "address" polycrisis? Three goals seem most relevant:

- To *prevent* polycrises, we need to reform global systems in ways that bolster their resilience (that is, maintain stable and desirable equilibria) and avert systemic crises that could spread into other systems.
- To *mitigate* polycrises that do occur, we need emergency response capabilities that limit crisis harms. Thus defined, mitigation involves reactive measures that alleviate crisis impacts but do not address the causes of crises; mitigation thus receives less attention below.
- To *navigate* through polycrises to better futures, we need to transform systems, steering them away from undesirable, crisis-prone equilibria to more beneficial and resilient equilibria.

The Cascade Institute's model of *systemic crisis* helps to conceptualize these three goals (Lawrence, Homer-Dixon, et al., 2024; Lawrence, Shipman, et al., 2024). It starts from the premise that global systems (such as the economy, health, energy, and the environment) generally function within a "dynamic equilibrium"—a set of conditions, stabilizing feedbacks, and structural relationships—that keeps the system's behaviours and properties within a "normal" range. A system goes into crisis when one or more systemic stresses combine with a triggering event to force the system out of its equilibrium (represented graphically as a "basin of attraction") into a state of disequilibrium that generates human harms through its volatility, unpredictability, and disruptiveness (see Figure 1). Polycrisis occurs when multiple systems push each other into such disequilibrium through their causal interconnections.

Figure 1. A stability landscape diagram of systemic crisis



Stresses gradually shallow a basin of attraction so that a trigger event can push the system out of equilibrium and into systemic crisis.

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A systemic crisis ends when a system returns to equilibrium, either the equilibrium that preceded the crisis or a new one with a different set of structures, behaviours, and properties. A new equilibrium may produce widespread benefits and be much better than the old equilibrium, or it could produce all sorts of harms, leaving people worse off than before. These possibilities create a dilemma in the search for positive pathways from polycrisis: some systems warrant crisis prevention strategies that avoid systemic crises by bolstering an existing equilibrium, while other systems warrant system transformations that steer through polycrisis to better, alternative equilibria.

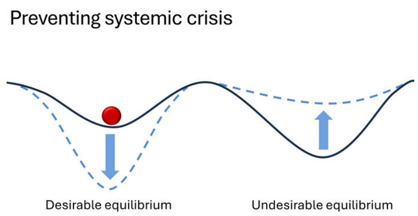
When a system has a desirable equilibrium, prevention strategies are most appropriate. They aim to bolster the resilience of the equilibrium so that the system does not go into crisis or returns to the desired equilibrium after a crisis. The post-World War II international security system, for example, has many desirable features, including its basis in decolonization, state sovereignty, and the prohibition of international aggression, alongside its many multilateral institutions that manage conflict and facilitate cooperation. This equilibrium, however, is under profound stress from redistributions of power, the resurgence of violent conflict, inequities between the global north and south, and faltering cooperation on global challenges. A systemic crisis (disequilibrium) of the international security system would most likely involve a catastrophic world war leading to a highly unfavorable new equilibrium (one with even more conflict, violence, injustice, and intransigence than seen today).

To avoid this future, a prevention strategy (as depicted in Figure 2A below) would deepen the resilience of the international security system's present equilibrium. The foundations of this equilibrium remain broadly favorable. Wide-ranging reforms could alleviate stresses by increasing fairness, peace, and cooperation. And preventive action should also manage the connections between the international security system and other global systems to reduce the potential for polycrisis to spread. An important goal, for example, is to ensure that the green energy transition does not create new international conflict in the form of a scramble for key resources.

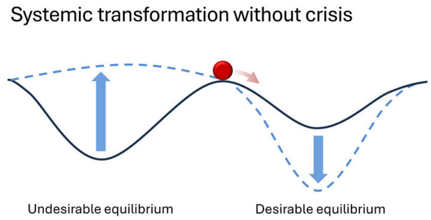
Figure 2. Strategies for preventing and navigating sytemic crises

Prevention

2A Preventing systemic crisis: To prevent trigger events from forcing a system out of a desirable equilibrium, this strategy increases the resilience of that equilibrium (deepens the basin) through structural reforms (left blue arrow). Preventive actions might also shallow an undesirable alternative equilibrium (right blue arrow) to keep the system from settling there.

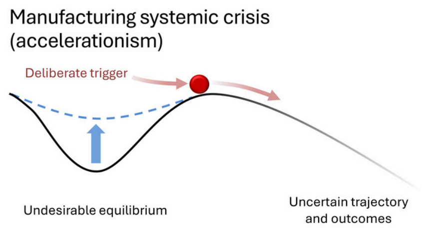


2B Transforming systems without crisis: Strategic actions might gradually transform the fundamental structures of a system, changing the stability landscape so that the system transitions to a new, more desirable equilibrium without going through crisis (disequilibrium) on the way. As the landscape changes, the system migrates to a new set of structures.

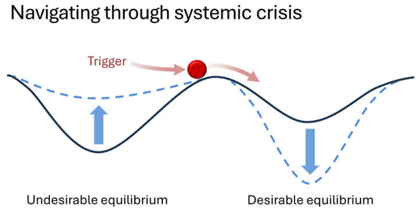


Navigation

2C Manufacturing systemic crisis (accelerationism): Some attempt to accelerate a system's entry into crisis by shallowing the existing equilibrium and deliberately creating a trigger event that forces the system into disequilibrium. Without first building an alternative, more desirable equilibrium, however, this strategy faces deep uncertainties and high risk. It may initiate a prolonged crisis, take the system in unintended directions, and eventually lead to an even worse equilibrium.



2D Transforming systems through crisis: A strategy more viable than accelerationism pursues deliberate systemic transformation by weakening an undesirable present equilibrium while also building new structures for a more desirable equilibrium. When a trigger event pushes the system into crisis, we can navigate through that crisis to a better equilibrium.



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In its attempt to avoid crisis, a prevention strategy reflects the negative association of the term "crisis" with suffering, destruction, and loss. But crises are just as often recognized as moments of opportunity—disruptions to the structures and assumptions of an undesirable status quo that open possibilities for fundamental change. Breakdown is often a necessary precursor to renewal and innovation, as captured by the adaptive cycle (Holling, 2001; see Box 1). The Covid-19 pandemic, alongside its immense devastation, drew many calls to "not let a good crisis go to waste" (though the opportunities for change were, arguably, squandered). And Ian Bremmer may be correct when he asserts in his book *The Power of Crisis* (2022, p. 11) that "history says we need a crisis" to push our leaders to address global challenges.[1] But that is undoubtedly a course fraught with peril. Crises throughout history have wrought some of the most profound social transformations, but those transformations range widely from positive and progressive adaptations to societal collapse (Hoyer et al., 2022, 2023).

Some global systems—such as energy and economy—have undesirable structures, behaviors, and properties, but are highly resilient in their present equilibria (the fossil-fuel energy regime and neoliberal economic order, respectively). These systems present us with a dilemma: we want the transformational opportunities created by systemic crises so that we can find more sustainable and equitable equilibria, but we do not want to suffer the harms of the systemic crises that lie between the present and preferred equilibria.

In such cases, we might pursue the preventive strategy of Figure 2A by attempting to reform these systems and avert systemic crises. But core systemic structures (and vested interests) may render our efforts slow, difficult, and ultimately ineffectual. In such cases, we need to transform those basic structures and move the system to a more favorable equilibrium while avoiding or limiting crisis in between. The strategy depicted in Figure 2B involves long-term efforts targeting systemic foundations that gradually change the shape of the stability landscape so that the system migrates to a better equilibrium without experiencing crisis. This strategy is ideal for transforming systemic equilibria while escaping the harms of systemic disequilibrium. But unfortunately, we tend to lack the resource commitments, long-term persistence, and broad-based cooperation required by this strategy.

If we are not capable of smooth, long-term structural transformations, then it will take a crisis to move global systems to more desirable equilibria. But this proposition can lead to fraught prescriptions.[2] Some may pursue the accelerationist strategy depicted in Figure 2C by forcing a system into crisis to speed its shift to another equilibrium.

[1] Some go so far as to argue that "Real social and political change *only* happens in times of crisis, because crisis is needed to discredit existing systems of worldviews, institutions, and technologies, and the structures of power that sustain them" (Homer-Dixon, 2020, p. 334, italics added.)

[2] In this vein, Bremmer (2022, p.186) argues that, "We need a 'Goldilocks crisis', one large enough to force our engagement but not so destructive that we can't respond effectively." It's quite a gamble that we can find one or make one. Most versions of *Goldilocks and the Three Bears* end with Goldilocks escaping the bears by jumping out the window and (presumably) returning to life as usual. But in the original 1831 version by Eleanor Mure, the bears throw Goldlocks onto the fire, douse her with water, then impale her on the church steeple. If we deliberately seek a Goldilocks crisis, it is highly uncertain which ending we will meet.

A better strategy for transforming systems with undesirable equilibria focuses not on creating trigger events but on developing viable and desirable alternative equilibria towards which we can navigate when crisis strikes (Figure 2D). This strategy aims to envision, experiment with, and pursue possible futures, and to strengthen the inter-systemic relationships that would enhance their stability. Here too, the notion that we can deliberately "steer" through a crisis remains questionable; to do so, we need a better understanding of what configurations of alternative equilibria among global systems are even possible, let alone broadly desirable. Section 3 thus introduces tools that could help us identify viable options.

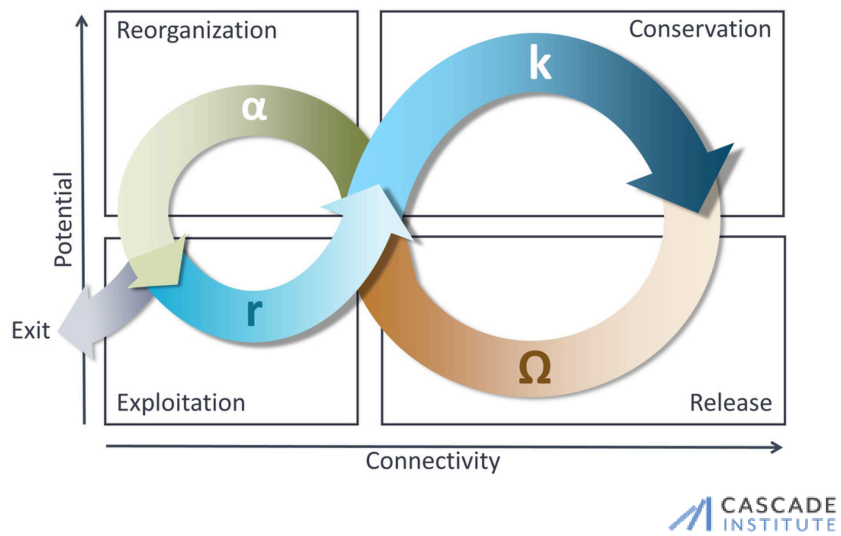
In sum, when a system is in a desirable—even if flawed—equilibrium, "addressing polycrisis" requires us to reform that equilibrium, insulate it from cascading crises in other systems, and increase its resilience. The strategy is to avoid polycrisis or mitigate its harms when it does occur. When a system is in an undesirable equilibrium—when its basic structures are harmful and leave scant prospects for reform—we should strengthen alternative possible equilibria so that, through crisis or smooth transition, we have possibilities ready and can minimize the harms of transformation.[3] Yet we must recognize the many difficulties and uncertainties inherent in such a strategy. "Accelerationist" attempts to prematurely force a system into crisis should be rejected as reckless and hubristic. And any systemic crisis necessitates rapid and effective mitigation efforts to limit its harms and stop its spread to other systems.

[3] It's worth emphasizing this distinction: prevention strategies maintain but reform basic system structures (staying within an existing basin but deepening it) while transformative strategies change the basic structures of the system (moving to an alternative basin). Prevention involves adaptation whereas transformation involves more fundamental change.

Box 1. Breakdown as a regular phase of the adaptive cycle

C. S. Holling's (2001) model of the adaptive cycle provides theoretical depth to the relationship between crisis and transformative change. He argues that complex adaptive systems—whether an ecosystem, a business organization, a political regime, or the entire planetary socio-ecological system—alternate between periods of stability and change, growth and breakdown, in recurring cycles. The adaptive cycle aptly captures breakdown (crisis) as a recuring source of transformation and renewal in the development of complex adaptive systems.

Figure 3. The adaptive cycle



Three system properties shape the four stages of the adaptive cycle:

- **Potential (wealth):** the range of possibilities open to a system based on its accumulation of capital (skills, resources, processes, functions, niches, etc).
- **Connectivity:** how tightly parts are linked to one another, and thus how quickly and deeply a change in one part of the system affects other parts.
- **Resilience:** the ability of a system to recover from unexpected shocks (in the diagram above, the background represents low resilience and the foreground represents high resilience).

The exploitation and conservation phases represent a long stable period in which established structures improve their efficiency in resource extraction until increasing specialization, high connectivity, and rigidity leave the system vulnerable to unexpected shocks.

Such shocks unleash a rapid period of breakdown in which parts of past structures are released and reorganized to create new variety upon which selection acts in subsequent exploitation and conservation phases. If the parts cannot successfully reorganize, the system dies.

Inspired by the adaptive cycle, Thomas Homer-Dixon (2006, p. 289) coined the term "catagenesis" to denote "renewal through breakdown", arguing that breakdown "is greatly disruptive to parts of the system, but it needn't be catastrophic overall, and it can produce exactly the conditions required for a burst of creativity, reorganization, and renewal." This conception of breakdown is similar to economist Joseph Schumpeter's notion of "creative destruction" wherein old economic structures and assumptions are recurrently destroyed in ways that free up resources for new innovations. And the "punctuated equilibria" model of technological and institutional change identifies a similar pattern in which long periods of "lock-in" and "structural deepening" reach a "critical juncture" that undermines existing arrangements and opens a range of new possibilities (before one new set of arrangements becomes locked-in) (Pierson, 2004; Arthur, 1989, 2011).

Reflecting on early responses to the Covid-19 pandemic, Berbés-Blázquez et al. (2022) argue that we should pursue different principles of resilience at each phase of the adaptive cycle. As the system moves into its conservation phase and approaches crisis, key principles include monitoring slow variables, maintaining a systems lens, and using adaptive management. These principles can help prevent and/or mitigate crisis. As the system enters the release phase, the most important principles are managing connectivity, using feedbacks to direct action, and learning. These principles can help mitigate and navigate the crisis. And as the system enters a reorganization phase, key principles include building redundancy and diversity, inviting participation, and exercising polycentric (decentralized and multilevel) decision-making. These principles can help nourish new and preferable systemic equilibria.

2. Three approaches to positive systemic change

The strategies for preventing, mitigating, and navigating polycrisis suggested above require a deep understanding of global systems and systemic change. This section surveys three prominent approaches to understanding systems change—leverage points, tipping points, and three-dimensional stability landscapes. They are presented in a progression, where each approach addresses shortcomings of the one preceding it but faces its own limitations. A careful examination of this progression reveals several important next steps for finding positive pathways through polycrisis, which are presented in Section 3.

2.1 Leverage Points

Many attempts to effect social change fail because they are not grounded in an understanding of the system producing the ills they hope to redress. Actions may target the symptoms of the underlying problem, one small part of the problem, or just a few of its many causes, but they do not address the system structures, processes, and relationships at the root of the problem. The system foils well-intentioned efforts, the problem recurs, and remedial actions may create unintended consequences—sometimes worsening the very problem they seek to solve or causing other harms (e.g., Stroh, 2015).

This recurring folly led systems theorist Donella Meadows (1999; Meadows & Wright, 2008) to a simple yet fundamental insight: problems that are systemic in nature require measures that are specifically tailored to the relevant system. Systemic issues must be addressed at their systemic sources, and only by doing so can we effect the big changes we seek. To do so, Meadows (1999, p. 1) identified twelve "leverage points": "places within a complex system (a corporation, an economy, a living body, a city, an ecosystem) where a small shift in one thing can produce big changes in everything." Each leverage point addresses a particular aspect of a system that can potentially shift the behaviours, properties, and performance of that system (Figure 4).

The order of the leverage points is important. From 12 to 1, they are arranged from those that are easiest to manipulate but have the smallest impact to those that are hardest to manipulate but have the largest impact. Meadows thus implies a clear inverse relationship between the feasibility and effectiveness of system interventions, which leaves us with the dilemma that the most impactful leverage points are also the most difficult to use.[4]

[4] Thomas Homer-Dixon (2020, p. 35) calls this predicament the "enough versus feasible dilemma": "On one hand, changes that would be *enough* to make a real difference—that would genuinely reduce the danger humanity faces if they were implemented—don't appear to be *feasible*, in the sense that our societies aren't likely to implement them, because of existing political, economic, social, or technological roadblocks. On the other hand, changes that do currently appear *feasible* won't be *enough*."

Figure 4. Donella Meadows' leverage points (places to intervene in a system)

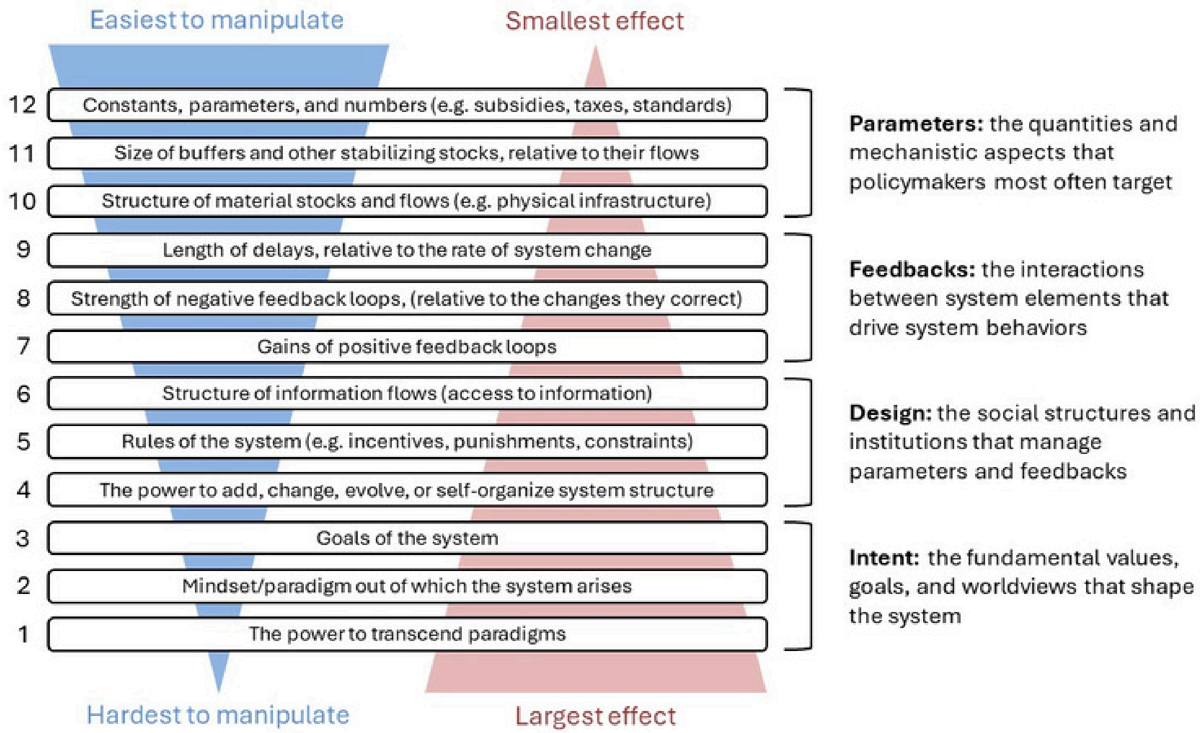


Diagram by Michael Lawrence based on Meadows, 1999.

The most effective systemic interventions, according to Meadows, shift the worldviews of the actors within the system. As their values, goals, and beliefs change, so does their individual behaviour, and the emergent behaviour of the system. If people shifted from an "empty world" paradigm that pursues boundless growth to a "full world" paradigm in which growth faces fundamental limits and should be valued differently, for example, societal transformations to sustainable systems would be much more plausible (Beddoe et al., 2009). But such paradigm shifts are virtually impossible to engineer. Thankfully, other levers are more feasible.

The trade-off Meadows identifies between the effectiveness and feasibility of leverage points, however, may exclude an important possibility. Her ranking creates a spectrum from low impact but easily manipulable leverage points to high impact but difficult to manipulate leverage points, spanning the top left to bottom right quadrants of Table 1. But some systems may have "high-leverage intervention points" that are both easy to manipulate and highly effective but have yet eluded our imagination. While this possibility may smack of wishful thinking, it should not be summarily dismissed.

Table 1. Feasibility versus effectiveness of leverage points

		***Feasibility* of manipulating leverage point**	
		Hard to manipulate	**Easy to manipulate**
***Effectiveness* of leverage point**	**High impact**	**Meadows' lower-number leverage points**	**High-leverage intervention points**
	Low impact	**Not of interest**	**Meadows' higher-number leverage points**

The concept of leverage points pervades discussions of systemic change. Some scholars (e.g., Farmer et al., 2019; Mealy et al., 2023) use the similar term "sensitive intervention points" and add to Meadows' list "critical nodes" which, "due to their position in the network… have an outsized impact on the system [in which] they are embedded" (Mealy et al., 2023, p. 695).[5] Others (e.g., the Cascade Institute) refer to "high-leverage intervention points." If we want to alter the behaviour of global systems, whether by changing the existing equilibrium or shaping a new one, leverage points are key sites of action. As a strategy for navigating out of the polycrisis, however, the leverage-point approach has three major limitations.

First, it tends to focus on a single system as the source of problems and the site of intervention. Many of our most pressing challenges, in contrast, stem from the intersections and interdependencies among multiple complex systems. Food production, for example, remains highly dependent on fossil fuel energy systems, and both suffer volatility due to their integration into the global financial system. Food and energy systems continue to drive climate change, and food production is particularly exposed to the consequent Earth system disruptions.

Though we can identify important leverage points in multiple inter-related systems, it becomes much harder to understand how manipulating a leverage point in one system will affect the behaviours of other systems. Systems may reinforce one another in ways that limit the effectiveness of leverage points in any one of them; or a leverage point in one system may trigger unintended consequences in another system.

[5] Critical nodes could be organizations that are "too big to fail"—whose failure would cascade throughout the system—and that should be bolstered to reduce systemic risk; they could be trend-setters and influencers who can help spread change and innovation; or they could be key obstacles to change (such as entrenched interest groups) whose influence must be countered.

Second, the approach does not explain *when* leverage points become "primed" so that small changes have big effects. Institutions and worldviews (i.e., leverage points related to "design" and "intent" in Figure 4) in particular tend to become deeply entrenched over long periods of time and stubbornly resist change. But at certain moments, drastic institutional and/or ideational shifts occur in short periods of time—consider the collapse of Apartheid in South Africa or the fall of the Cold War Eastern Bloc. We need to better understand when leverage points appear and become most sensitive.[6]

And finally, the search for leverage points can—if we are not careful—devolve into wishful thinking about magic-bullet solutions. Meadows (1999, p. 1) herself suggests this hazard when she notes that the concept of a leverage point "is not unique to systems analysis—it's embedded in legend. The silver bullet, the trimtab, the miracle cure, the secret passage, the magic password, the single hero or villain who turns the tide of history." It may be a basic feature of human psychology that the more complex the problems we face, the simpler the solutions we seek. But we must consciously resist this tendency, lest we fall back into the very non-systemic thinking Meadows sought to rectify. And it may be the case that big systemic changes require big systemic interventions—and perhaps even systemic crises to open opportunities for change.

[6] Mealy et al. (2023, p. 695) thus identify "critical points in time" as a type of sensitive intervention point "where windows of opportunity open up that make systems more 'ripe' or primed for change . . . . At these points in time, structural changes that would normally be very difficult to implement can become much easier."

2.2 Tipping Points

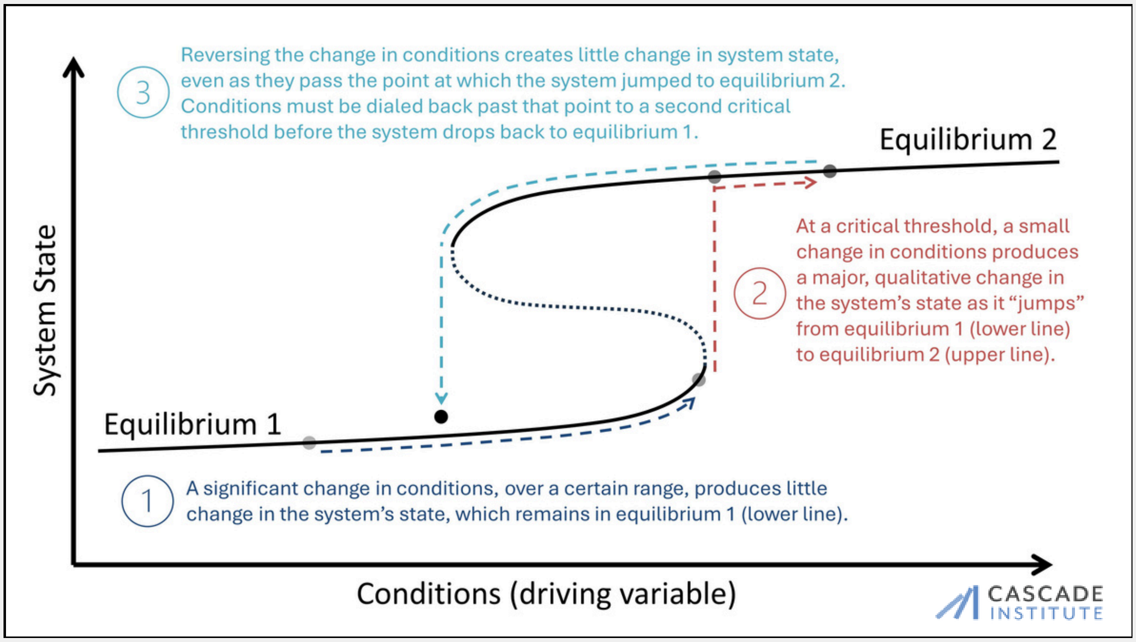
In just the past few years, the concept of a "tipping point" has become ubiquitous in discussions of sustainability and transition, often conveyed through phrases like "positive tipping points" or "social tipping points." Milkoreit and colleagues precisely define a tipping point as the "threshold at which small quantitative changes in the system trigger a non-linear change process that is driven by system-internal feedback mechanisms and inevitably leads to a qualitatively different state of the system, which is often irreversible" (Milkoreit et al., 2018, p. 9). Activists, policymakers, and others wishing to accelerate beneficial change often hope to exploit this basic phenomenon by making a relatively small intervention that tips a social or technological system from one equilibrium, such as fossil-fuelled transportation, to another more sustainable equilibrium,[7] such as electrified transportation.

The growing literature on tipping points makes several advances over the leverage points approach discussed above. First, much (though not all) of it builds on the more rigorous "critical transitions" model of how a small change can make a big difference (Scheffer, 2009). As depicted in Figure 5, in this model gradual change in a key driving variable (or "conditions") will, over a certain range, produce little qualitative change in a system. A set of stabilizing feedbacks keeps the system in a particular equilibrium marked by persistent properties and behaviours. When that gradual change reaches a "critical threshold," however, it overcomes those (now weakened) stabilizing feedbacks and unleashes a positive feedback that rapidly "flips" the system to a new equilibrium—one with a different set of properties and stabilizing feedbacks.

Once completed, the transition is not easily reversed; the new set of stabilizing feedbacks maintains the new equilibrium even when the driving variable recedes below the level at which the transition occurred. That variable must decline even further, before the system flips back to the earlier equilibrium. (That is to say that forward and backward transitions occur at different thresholds, a phenomenon that specialists call "hysteresis.")

[7] Note that some refer to an equilibrium as a "state" or "regime," and therefore use the terminology of "state shift" or "regime shift" rather than "critical transition."

Figure 5. A critical transition as the model of a tipping point



The characteristic S-curve of a critical transition (tipping point) has been found to accurately represent non-linear change in such varied systems as ecologies, human brains, and societies (Scheffer, 2009). For example, a moist, vegetated ecosystem (equilibrium 1) will persist even as levels of rainfall decline (i.e., as dry conditions increase) because plant leaves trap and maintain sufficient moisture for vegetation to thrive. At a critical threshold, however, leaves begin to dry out, moisture escapes, more leaves dry out, more moisture escapes, and this positive feedback drives the ecosystem from a lush, vegetative equilibrium (1) to a dry, arid one (equilibrium 2). To reverse the transition, rainfall would have to increase (i.e., dry conditions reverse) beyond the level at which the flip occurred, so that enough leafy plants can regenerate to maintain the surface moisture required for more vegetation to grow, and thereby restart the stabilizing feedback of the first equilibrium.

Just as positive feedbacks drive critical transitions in ecosystems (see Figure 5), they can also drive major change in anything from technologies to norms in social systems. These positive feedbacks can take several forms. In what are called *positive network externalities*, the more people that use an innovation, the more beneficial (or less costly) it becomes to all users, which then causes even more people to use it. The greater the number of users of a particular social media platform, the greater its value to each user, because it enables even more connections; the more a green energy technology is employed, the cheaper and better it becomes for all due to economies of scale and design improvements. Increasing use produces increasing returns to users, which in turn encourages more use.

Other social tipping points involve a *critical mass*: once a certain number of people adopt an innovation, the rest follow. Chat room experiments, for example, suggest that even a relatively small number of strongly opinionated actors can constitute the critical mass that tips the whole group to a new perspective (Centola et al., 2018). A critical mass can thus trigger a "cascade of behaviour change that rapidly increases the acceptance of a minority view" (ibid., p. 1116). Similarly, once the price of a given product drops to a certain threshold, often a critical mass of people will buy it, which then encourages others to follow suit (even if the price subsequently increases). Additional positive feedbacks (tipping point mechanisms) include: self-fulfilling beliefs, norm cascades, learning curves, and bandwagon effects (Farmer et al., 2019).

By highlighting feedback mechanisms, the critical transitions model helps the tipping point literature make a second major advance: it more clearly identifies practical strategies for pushing systems over a tipping point—for priming them for tipping. Some strategies seek to destabilize a system in its existing equilibrium by weakening its stabilizing feedbacks and pushing it towards a critical threshold (Lenton, 2020; Winkelmann et al., 2022). Higher carbon prices, for example, can destabilize fossil fuel dependence. Other strategies support enabling conditions that could strengthen the stabilizing feedbacks of an alternative equilibrium. If green energy is made easily available at low cost, then market forces and buyer preferences could all propel and maintain a critical transition to a green-energy equilibrium, for example. Other interventions, such as policy changes, public awareness campaigns, and shaming, can help "lock-in" the new equilibrium by increasing the costs of switching back and by embedding the new equilibrium in a broader context of new institutions, norms, and expectations (see: Arthur, 1989; Pierson, 2004).

More generally, we can evaluate potential interventions for their trigger potential (can they cause change?), impact potential (how large of an impact will they have?), and risk potential (what trade-offs, uncertainties, and unintended consequences might be involved?) (Farmer et al., 2019; Mealy et al., 2023). Applying such criteria to 20 green energy policy options, Mealy et al. (2023) found that investing in green energy technologies to reduce their costs and creating central bank policies that divert investment from "brown" to green tech ranked highest in speed, size, and scale of impact.[8]

In a third advance over the leverage point approach, the tipping point literature pays more attention to the *multiple* systems implicated in social transformations and the connections between those systems. "Creating a world of zero greenhouse gas emissions is a revolutionary enterprise that will require vast changes to our physical infrastructure, economy, and society, and their interactions with each other. There is strong coupling among these different domains, which makes models built within silos unable to provide the guidance needed" (Farmer et al., 2019, p. 134).

Accordingly, the *Global Tipping Points Report* (GTPR) (Lenton et al., 2023) identifies tipping points that would cut carbon emissions by generating change in multiple systems, including energy/power, transport and mobility, food and agriculture, political systems, legal systems, and financial systems. The report focuses on the demand side of economies and the ways in which social behaviours can encourage companies to make green choices. *The Breakthrough Effect* (Meldrum, 2023) describes "super-leverage points": tipping points that are highly interconnected with multiple systems that, if triggered, would produce cascading green change. For instance, the use of green ammonia could immediately trigger green tipping points in the food and shipping system, which would then unlock technology, manufacturing, and price-parity in a way that would cascade into green energy, steel production, and aviation.

Not all inter-systemic effects are beneficial, however. Interventions have "trade-offs in the form of adverse associated outcomes in other areas . . . . For instance, removing fossil fuel subsidies, extraction permits or otherwise restricting fossil supply could cause (temporary) higher energy costs, disproportionately affect low-income households, and lead to a political backlash" (Mealy et al., 2023: 702). Better knowledge about these interactions can help prevent such unintended harms in other systems.

[8] Notably, studies often do not agree about which tipping point interventions are most promising. *The Breakthrough Effect* report (Meldrum, 2023), for example, highly recommends the use of green ammonia in fertilizer production, but that option ranks much lower in the evaluation of Mealy et al., 2023.

As with the leverage points approach, the tipping point approach has several limitations. First, the literature risks conceptual overstretch by pigeon-holing diverse patterns of social change into the tipping points model. There is no *a priori* reason to assume that every social transformation (and even every non-linear social transformation) involves a critical transition. It is more plausible to assume that social change can follow a wide variety of patterns, and a critical transition is but one.

To avoid conceptual overstretch, Milkoreit (2023) implores scholars to use the term "tipping points" more diligently to refer specifically to processes of change that display the four key characteristics of the critical transitions model: (1) multiple possible system states, (2) abruptness (non-linearity) of change, (3) feedback mechanisms, and (4) irreversibility. She reviews many peer-reviewed publications that identify phenomena (historical, current, or potential) as tipping points without presenting evidence of these features. And tipping points may operate differently in social systems than they do in ecosystems (where the critical transition model originated), because humans have self-reflectivity, culture, agency, sociality, power structures, group identities, and multiple overlapping social networks.

Second, the tipping points literature can be misleading insofar as it focuses on the proximate actions that tip a system rather than the long-term processes that push a system to the threshold of tipping. By emphasizing the small, immediate event that generates a big, systemic transition, the approach is vulnerable to "trigger fixation" (Lawrence & Homer-Dixon, 2023) and may, like the leverage points approach, pursue silver-bullet solutions. At the same time, many tipping point analyses advocate actions intended to destabilize (or shallow) an existing equilibrium in ways that may produce gradual, rather than non-linear, change through the accumulation of large, long-term actions rather than the force of a small, proximate one (Olsson & Moore, 2024). The tipping points approach is most relevant to systems that have tipping points and, consequently, the potential for large and rapid change, but not all systems necessarily possess these features.

Third, although the tipping point literature does consider relationships across multiple systems, key tipping examples tend to be narrow in scale, scope, and specificity. The tipping points literature draws heavily on the socio-technical transitions literature (e.g., Geels & Ayoub, 2023) to identify potential tipping points in technology adoption, often at national scales, that will contribute to a green energy transition and fight climate change.

A prominent example is the cost threshold at which Norway tipped from the predominance of gasoline-fuelled vehicles to electric vehicles (Mersky et al., 2016). Similarly, *The Breakthrough Effect* (Meldrum et al., 2023) emphasizes specific tipping points like shifting to green ammonia in fertilizer production. But as Ollson and Moore (2024, p. 65) remark, "transformation is a non-linear process that involves more than diffusion of specific technologies, behaviors, or practices." The literature leaves a gap between specific technological (and sometimes normative) tipping points and the broader societal transformations that are ultimately sought.[9]

Additionally, "too narrow of a focus on technological innovations or a specific problem such as carbon emissions" can result in positive changes in one area that "have unintended and unexpected negative consequences in other parts of the system, including biodiversity and justice" (Olsson & Moore, 2024, p. 60). Though conscious of many inter-systemic effects, the tipping point literature does not yet consider the full range of systems implicated in global polycrisis (which could suffer such unintended harmful consequences), nor the full extent of systemic changes necessary to confront the polycrisis as a whole. As noted in the title of a recent polycrisis policy brief, "mitigating global warming is not our only problem" (White, 2023). In particular, the tipping points literature does not sufficiently explore the geopolitical conflicts and domestic political tensions that will arise from the green transition (which affect supply chains, for example), nor the transition's knock-on effects in other global systems such as health. And the literature's present emphasis on technological and (to a lesser extent) institutional change sidelines questions of ideational change—the paradigm shifts that Meadows identifies as the most effective leverage point—from discussions of social transitions.

Mealy et al. (2023) do admit that, while their framework focuses on individual interventions, future work must examine the full range of impacts across whole policy portfolios. And although the GTPR recognizes multiple systemic interactions involved in tipping cascades (spanning sociotechnical, sociopolitical, and socioecological systems), it highlights the need for much greater knowledge about these interactions as a research priority (Lenton et al., 2023).

[9] For example, it is not clear when or how adoption of individual green technologies in specific sectors and countries add up to a systemic regime shift from a fossil fuel equilibrium to a green one.

Finally, the literature on tipping points may overestimate our ability to deliberately design, control, or steer tipping phenomena towards outcomes we desire. The concept of intentionality in exploiting "social tipping points" is relatively new, exploding in usage between 2020 and 2021 (Milkoreit, 2023). Our ability to deliberately steer cascading transitions into a desirable new equilibrium thus remains largely speculative.

"At the moment," Milkoreit (2023, p. 4) argues, "there is little confidence among scientists and policy makers in our ability to predict and avoid climate tipping; let alone manage its social impacts. Yet, there is a curious degree of confidence in our collective ability to initiate and control rapid and radical change in social systems. Our attitudes toward control of social tipping processes is even more puzzling, given that our understanding of social systems is significantly weaker than that of natural ones and that their complexity tends to be higher."

The first step in locating a tipping point is to identify the key driving variables (or "control" variables), but it is extraordinarily difficult to do so in complex systems that are highly interconnected to other complex systems. Tipping points research has focused primarily on fostering enabling conditions and mounting interventions to reach a tipping point, and less on how to create a new equilibrium and guide the system to it once the tipping point has been breached. This problem is especially acute for systems that could transition into several different possible equilibria, some desirable, and some disastrous. To navigate through polycrisis, we must better understand the possibility landscape of viable configurations among multiple global systems. Three-dimensional stability landscape diagrams—the subject of the next section—can help advance our thinking about multiple equilibria and the difficult pathways between them.

2.3 Multi-systemic (3D) stability landscapes

The positive tipping points literature uses two-dimensional stability landscape diagrams (like those in Figures 1 and 2) to depict the diffusion of specific technologies, behaviours, or practices. But "conceptualizing social tipping as a single threshold alone is insufficient; instead, there is a need to consider a full range of tipping dynamics, including the capacities to navigate the entire tipping process" (Ollson & Moore, 2024, p. 61). An important outgrowth of the tipping points literature addresses that need by using *three*-dimensional stability landscape diagrams to represent much broader systemic transformations.[10] The extra dimension does not simply make for more engaging diagrams (see Figures 6 and 7); it also enables us to consider the several equilibria that emerge from the interaction of *multiple* systems in the possibility landscape (e.g., Westley et al., 2011, p. 767).

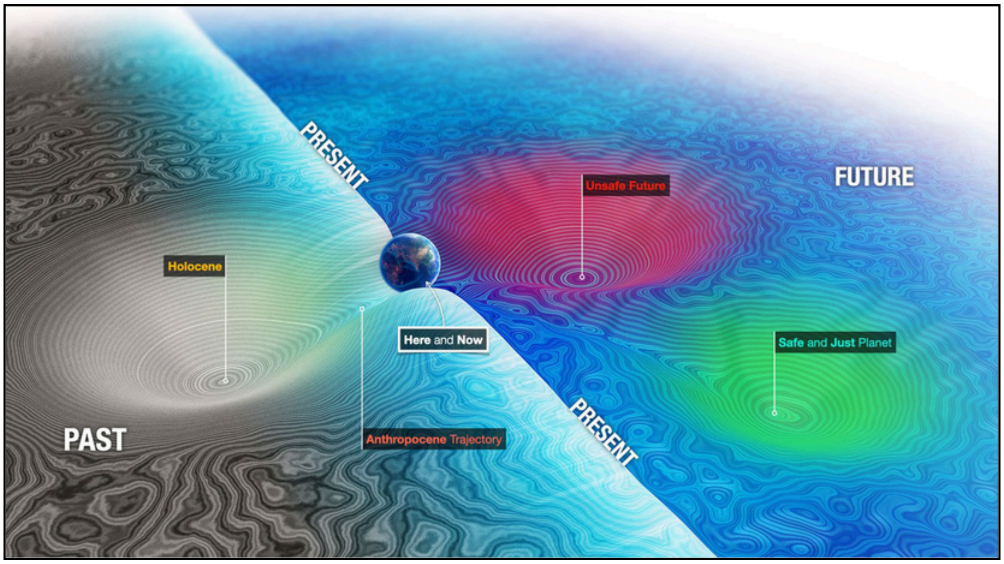
The x- and z- axes in these diagrams represent, metaphorically, an n-dimensional state space encompassing all the relevant state variables of the system in question. As in 2D stability landscape diagrams, including those in Figures 1 and 2, the y-axis represents stability, such that lower positions on the diagram are more stable. But where 2D diagrams usually feature a single alternative basin of attraction, 3D stability landscapes can capture a multiplicity of possible equilibria and help us think about how we might steer across the landscape towards some equilibria and away from others.

In the examples below, the landscape portrays possible configurations of Earth's combined system-of-systems—that is, the tightly connected set of ecological, technological, and social systems that now spans the planet. Each equilibrium (or basin of attraction) represents a self-reinforcing configuration of system structures that produce a stable state for this system-of-systems.

Rockström et al. (2021), for example, present the 3D stability landscape shown in Figure 6 that depicts all possible states of Earth's life support systems and of human well-being. They note that each sub-system's state should not be considered separately (as is usually done with depictions of "planetary boundaries"), because the systems interact and feedback on one another to shape the overall stability landscape (Lade et al., 2019).

[10] Some may not see three-dimensional stability landscapes as a distinct approach to systems change, but rather a subset of the tipping points literature or a widely used tool of sustainability science more broadly. This section and the next, however, suggest that 3D landscapes have unique advantages for thinking about positive pathways through polycrisis and offer a helpful step towards further methodological advances. For a detailed discussion of stability landscapes—including three-dimensional stability landscapes—in relation to various conceptualizations of resilience, see: Folke et al., 2010; and Walker et al., 2004.

Figure 6. Earth system stability landscape from Rockström et al. (2021)



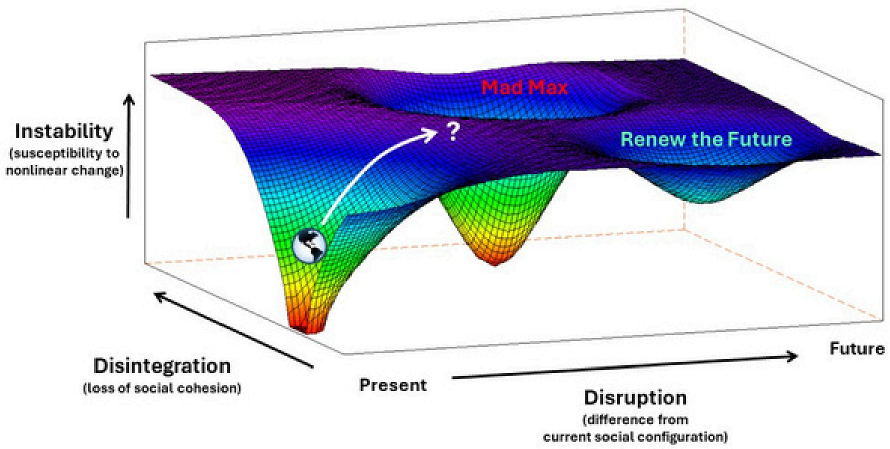
Homer-Dixon (2023) presents a three-dimensional stability landscape (Figure 7) that highlights two possible future equilibria for the world depending upon the amount of social cohesion and the extent of change the world experiences over the coming decades:[11]

- A "Mad Max" equilibrium that involves "a descent into a kind of Hobbesian state of nature—a vicious zero-sum struggle of all against all as scarcity worsens [so that] institutions, trust, and social order break down" and we lose the ability to cooperate to solve global problems (Homer-Dixon, 2020, p. 51).

- A "Renew the Future" equilibrium in which people enjoy broad opportunities within the bounds of safety and justice, share a global "we" identity that includes both humans and nature, and jointly pursue the superordinate goal of rebuilding nature (ibid., pp. 342-369).

[11] In *Commanding Hope* (2020), Homer-Dixon describes similar "Mad Max" and "Renew the Future" basins of attraction, but as possible worldviews in a "mindscape" (an ideational stability landscape) defined by 15 ideological dimensions rather than multiple systems.

Figure 7. A 3D stability landscape with three equilibria



Courtesy of Thomas Homer-Dixon; image produced by Chris Carignan

Although the landscape in Figure 7 represents (metaphorically) the n-dimensions that encompass all possible state variables of multiple systems, the x- and z- axes in this three-dimensional diagram are labeled to capture particular broad characteristics of that state space (in this case, overall levels of disintegration and disruption). And, for simplicity's sake, this diagram presents just two possible future equilibria; many more are likely present.

As an additional advantage, 3D stability landscapes help us think about the "evolutionary traps" that can lead us astray from positive pathways to desirable equilibria. In human societies, an evolutionary trap refers to a practice that was once highly adaptive and beneficial (such as the use of fossil fuels) but which persisted long after altered circumstances rendered it harmful and maladaptive (Søgaard Jørgensen et al., 2024). Traps include: overshoot of available resources, deep socio-political divisions, contagion through tightly coupled global networks, myopic short-term planning, and disconnection from the ecological impacts of human actions. Technological traps can cause locked-in infrastructure, severe and long-term impacts from pollution, mis-/dis- information, and existential risk posed by weapons of mass destruction.

On a 3D stability landscape, evolutionary traps do not represent equilibria; instead, they are defining features shared by multiple basins that ensure those equilibria are bad for the planet and for human well-being. Rather than stable states or equilibria, these evolutionary traps (or "Anthropocene traps") are "better described as stable (attracting) trajectories" (ibid., p. 8).

We can therefore visualize evolutionary traps as broad slopes in the landscape that —to the extent that we remain locked into overshoot, division, short-termism, and other traps—steer humanity's evolutionary pathway towards sections of the landscape that feature undesirable equilibria or prolonged systemic crisis (in which we remain on a high plane without settling into an equilibrium). Evolutionary traps limit our ability to take positive pathways across the landscape to the most desirable equilibria. [12]

Three-dimensional stability landscapes offer a powerful visualization tool that allows us to think in sophisticated ways about evolutionary pathways. As an approach to systems change and navigating polycrisis, however, this tool has (at least) two major limitations.

First, stability landscapes offer no practical guidance as to how we can deliberately maneuver across them, steering a course towards desirable equilibria and circumventing undesirable equilibria. Any positive pathway will have to: (1) contend with path dependencies (or lock-ins) of worldviews, institutions, and technologies (Beddoe et al., 2009); (2) manage diverse and often conflicting interests and values, including powerful vested interests; and (3) resist the pull of evolutionary traps. These challenges are especially daunting because human agency is decentralized and distributed across multiple scales (Olsson & Moore, 2024, pp. 65-66). No one leader or group of leaders has sufficient authority to guide the way; humanity's path across the landscape is necessarily an emergent phenomenon.[13]

Second, three-dimensional stability landscapes do not tell us how to find configurations of Earth's multiple systems that will create stable and beneficial equilibria—that is, basins on the landscape to which we'd like to navigate. We need to consider how the reconfiguration of one system (say involving an energy transition from fossil fuels to renewables) might enable or constrain possible configurations of other systems (say, by lowering the energy available to food production) and how those other systems might in turn enable or constrain the reconfiguration of the first system (more localized and equitable models of food production could favour decentralized electrical grids, for example).

[12] Peter Søgaard Jørgensen and colleagues (2024, p. 1) thus worry that "we as humans could be on the verge of being, or already have become, locked in to some form of undesirable trajectory with persistent crises and growing negative impacts on human well-being."

[13] Though some remain optimistic about our ability to evolve intentionally (e.g., Ellis, 2024).

As we navigate the polycrisis, we need to better understand how each global system's configuration either supports or undermines other systems' configurations.[14] And if and when we can determine which multi-systemic arrangements are stable and beneficial basins of attraction, we face the additional political challenge of deciding collectively which basin is most desirable and what pathway we should follow to reach that equilibrium.

Table 2 summarizes the strengths and weaknesses of the three approaches to understanding systemic change discussed in this section. To find positive pathways through the polycrisis, we need now to move beyond the visual metaphor of 3D stability landscapes to identify sets of stable, beneficial, and mutually reinforcing configurations among multiple global systems in a rigorous and comprehensive manner. The next section outlines how this might be done.

Table 2. Advances and limitations of existing approaches to understanding systemic change

Approach	Advances	Limitations
Leverage points (Meadows)	• Recognizes that systemic problems require systemic solutions—i.e., interventions that target features of the relevant system. • Identifies trade-offs between feasibility and effectiveness of interventions.	• Focuses on interventions in a single system. • Does not explain when (in which circumstances) leverage points are sensitive. • Risks wishful thinking about silver bullet solutions.
Tipping points (Lenton and Scheffer)	• Provides a more rigorous understanding of systems change and its conditions (critical transitions). • Considers (some) inter-systemic dependencies and impacts. • Offers guidance on accelerating social tipping.	• Relies on examples of limited breadth and scope; multi-systemic interactions remain under-emphasized. • Emphasizes the tipping event rather than long-term processes that generate tipping behaviour. • Risks conceptual overstretch if all social change is understood in terms of tipping points. • Makes dubious assumptions about intent, control, and the desirability of social tipping.
Multi-systemic stability landscapes (Rockström, Steffen, Homer-Dixon)	• Considers multiple systems as they interact to form with multi-systemic equilibria. • Countenances multiple possible equilibria in the stability landscape. • Enhances our understanding of evolutionary traps.	• Provides no practical advice on navigating (steering) through the landscape. • Does not identify stable, multi-systemic equilibria. • Underestimates the politics of defining desirable equilibria and moving collectively towards them.

[14] In a similar vein, Søgaard Jørgensen et al. (2024) find that some evolutionary traps reinforce others, so that the presence of one may bolster the influence of others. But the elimination of some can also help free us from others: "addressing a couple of the traps could help alleviate several others. Foremost among such traps are global division, short-termism and overconsumption, as well as the growing concerns about technological autonomy, which all cause eight amplifying interactions" with other traps (ibid., p. 8).

3. Next steps on positive pathways

Our review of existing approaches to systemic change reveals several crucial knowledge gaps that must be addressed if we are to find positive pathways through polycrisis.

- We must consider the full range of global systems that are necessarily involved in efforts to prevent, mitigate, and navigate polycrisis. Existing approaches, at best, consider only a few of the implicated systems.
- We must explore the interdependencies and trade-offs between possible configurations of global systems insofar as the organization of one system creates opportunities and constraints for configurations of all other systems—and the configurations of those other systems feed back upon that of the first.
- We need to use the multi-systemic knowledge outlined above to identify equilibria in which the configurations of all global systems are mutually reinforcing and therefore stable. We must then determine which of these equilibria are most desirable, benefiting both humans and the ecosphere while advancing justice.
- We need to formulate inclusive strategies, involving distributed forms of agency, to find pathways to desirable equilibria. Such strategies require that we effectively manage the deeply political nature of "system steering" in the context of diverse worldviews, interests, values, and capacities, amidst widespread conflicts and unequal power structures.

Analysts are already using several helpful tools to address these challenges. Causal loop diagrams (Lawrence, 2024) help us understand feedbacks that maintain a given systemic equilibrium and to explore the interactions between equilibria. Polycrisis mapping tools (Lawrence, Shipman, et al., 2024, pp. 19-15) help us chart the causal relationships between stresses, triggers, and crises across multiple systems and forecast how those systems might co-evolve. Scenario planning and forecasting exercises (e.g., Ogilvy, 2015) identify key drivers of global-structural change and use informed narratives to consider possible futures. And actor maps (e.g., Gopal & Clarke, 2015) help identify the relationships—both cooperative and conflictual—between relevant individuals and organizations so that we can understand the opportunities, roadblocks, and power struggles facing systems change.

One currently under-used method shows great promise for addressing the first three challenges above, while also providing some help on the fourth: cross-impact balance (CIB) analysis. This method can allow analysts to map the n-dimensional possibility space of the global system-of-systems in a more precise and exhaustive manner than the visual metaphor of 3D stability landscape diagrams.

Cross-impact balance analysis (Weimer-Jehle, 2006) is a mathematically rigorous method for identifying possible stable futures in systems that involve many interdependent variables. Analysts first identify all the candidate systems' key state variables (called "descriptors") and the different quantitative or qualitative "states" those variables may take. They then quantify in a matrix the degree to which each variable state promotes or inhibits every other variable state. These judgements about impact can be derived from various sources, including literature reviews, expert consultations, and experienced estimation.[15] Figure 8 provides an example of a CIB matrix.

Software called Scenario Wizard then assesses every possible scenario (i.e., every combination of descriptor states) to see if that combination is internally consistent (i.e., non-contradictory) given the influence of each descriptor on every other descriptor. In a consistent scenario, each descriptor state promotes other descriptors' states in ways that align with the initial state. Generally, only a few of the many possible scenarios form a "self consistent network of influences in the system" (ibid., p. 342).

We can use CIB to find stable multi-systemic equilibria towards which humanity can navigate in the polycrisis. Each relevant global system can be represented as a CIB descriptor; each possible set of arrangements, structures, and behaviours that this system might take can be a descriptor state. Internally consistent scenarios will represent configurations of all global systems in which each system's structure supports the structure of the other systems, and vice versa.

CIB analysis can thus provide a rigorous search of the vast, n-dimensional possibility space of the global system-of-systems. It can assess a multitude of inter-systemic interactions far beyond the computational power of the human brain, identifying potentially beneficial and stable futures, including surprising ones that have yet to be imagined.

Scenario Wizard's computations assign each possible scenario (each collection of systemic configurations) an "impact balance score," which is a measure of its (in-) consistency. These scores can be translated into a topographical space (one much more complex than a 3D stability landscape), that depicts the breadth and depth of different multi-systemic basins of attraction (equilibria). And the model can help us better understand the basin in which we presently reside, especially the resilience of the status quo, for better or worse.

[15] A key advantage of CIB analysis is that it can incorporate everything from rigorously quantified data to rough qualitative assessments in a single matrix. It can blend nominal, ordinal, interval, and ratio scales of data. CIB can then generate important insights into the causal impact of qualitative phenomena such as worldviews that are otherwise difficult to integrate into "hard" data analysis.

Figure 8. A cross-impact balance matrix of oil price and geopolitical stability

		1. World GDP growth			2. Borrowing industrial countries			3. World tensions			4. Cohesion OPEC			5. Oil price			
		< 2 %/yr	2 – 3 %/yr	>3 %/yr	high	medium	low	Strong	Moderate	Weak	Strong	Moderate	Weak	< 20$	20 – 35$	35 –50$	> 50$
1. World GDP growth	< 2 %/yr				2	0	–2	2	0	–2	0	0	0	2	1	–1	–2
	2 –3 %/yr				–1	2	–1	0	0	0	0	0	0	–1	1	1	–1
	>3 %/yr				–2	1	1	–1	0	1	0	0	0	–2	–1	1	2
2. Borrowing industrial countries	high	1	0	–1				1	0	–1	0	0	0	0	0	0	0
	medium	0	0	0				0	0	0	0	0	0	0	0	0	0
	low	–1	0	1				–1	0	1	0	0	0	0	0	0	0
3. World tensions	strong	1	0	–1	1	0	–1				1	0	–1	–3	–2	3	2
	moderate	0	0	0	0	0	0				0	0	0	0	0	0	0
	weak	–1	0	1	–1	0	1				–1	0	1	1	2	–1	–2
4. Cohesion OPEC	strong	0	0	0	0	0	0	0	0	0				–3	–2	3	2
	moderate	0	0	0	0	0	0	0	0	0				–1	1	1	–1
	weak	0	0	0	0	0	0	0	0	0				1	1	0	–2
5. Oil price	< 20$	–2	0	2	–1	0	1	0	0	0	–2	0	2				
	20 – 35$	–1	0	1	0	0	0	0	0	0	2	–1	–1				
	35 – 50$	0	0	0	0	0	0	0	0	0	0	0	0				
	> 50$	1	0	–1	0	0	0	1	0	–1	–1	0	1				
States according to test–scenario:				↓			↓			↓	↓				↓		
Impact balances:		–3	0	3	–3	1	2	–2	0	2	1	–1	0	–4	–1	3	2
States according to impact balance:				↑			↑			↑	↑					↑	

C 23

C23 (3,1)

Impact score of state "Borrowing medium"

Impact balance of descriptor "Cohesion OPEC"

CIB matrix from: Weimer-Jehle 2006 [15]

CIB utilizes descriptors (here: World GDP, Borrowing industrial countries, World tensions, Cohesion OPEC, and Oil Price) with multiple distinct states (e.g., high, medium, and low for the descriptor "Borrowing industrial countries"). Researchers then insert judgments of how much each state promotes, inhibits, or has no effect on the likelihood of each other state occurring. These judgments form a matrix in which each possible scenario can be assessed to determine consistency and impact score.

“Succession analysis”—an additional application of Scenario Wizard—can help us chart pathways to desirable equilibria. For each inconsistent scenario, the software assesses where the various inter-systemic influences push the overall system, running successive iterations until the system reaches an internally consistent scenario. (An inconsistent scenario pushes the system towards a different inconsistent scenario, which then pushes the system towards yet another inconsistent scenario, until it eventually finds a consistent one.) Starting from a nearly consistent scenario (in which all but one state are consistent), the inconsistent descriptor can then be “walked” in successive steps until a consistent scenario in found. Succession analysis can thus help identify the intermediate configurations that the systems must traverse to reach a stable multi-systemic equilibrium.

Finally, CIB can be used to “force” certain conditions on the system to determine which stable states remain possible after those conditions are imposed (Weimer-Jehle, 2023). For instance, by forcing a particular state on the energy system (say, a full transition to electric vehicles, enacted through policy), CIB analysis can tell us which states remain possible in other systems, such as the food production system. CIB can thereby help determine whether an intervention ultimately lowers the risk that the full set of interlinked systems will migrate towards a bad future (an undesirable equilibrium).

Steering systemic change in the polycrisis—whether by exploiting leverage points, pushing global systems over tipping points, or navigating across stability landscapes—is an uncertain prospect at best. But cross-impact balance assessment should at least give us a better sense of the landscape, its complex topography, and possible positive pathways to better futures.

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Special thanks to Scott Janzwood, Thomas Homer-Dixon and Ajay Gambhir for comments and editing, and to Nicole Pointon for document layout, of this report.