TECHNICAL PAPER

A call for an international research program on the risk of a global polycrisis

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Abstract

Humanity faces an array of grave, long-term challenges, now often labeled "global systemic risks." While scientific knowledge of the individual risks spawning these crises is deep, our understanding of causal links among risks remains shallow. This observation raises two key questions: What causal processes might be accelerating and amplifying risks within global natural and social systems and synchronizing risks (and their concomitant crises) across these systems? And what might humanity do to mitigate or even reverse these processes? We offer a novel analytical framework to aid identification of hitherto unrecognized, complex teleconnections and self-reinforcing feedbacks among global systems. We argue that the ultimate result of such unrecognized processes could be a global polycrisis—a single, macro-crisis of interconnected, runaway failures of Earth's vital natural and social systems that irreversibly degrades humanity's prospects. We therefore call for a global scientific collaboration to discern causal mechanisms that might generate a polycrisis and actionable policies to mitigate this risk.

Keywords

polycrisis, systemic risk, risk synchronization, complexity, feedbacks, substrate

1. Introduction

Humanity faces an array of grave, long-term challenges, now often labeled “global systemic risks.” They include climate heating, biodiversity loss, pandemics, widening economic inequalities, financial system instability, ideological extremism, pernicious social impacts of digitalization, cyber attacks, mounting social and political unrest, large-scale forced migrations, and an escalating danger of nuclear war. Compared to humanity’s situation even two decades ago, most of these risks appear to be increasing in severity (risk amplification) at a faster rate (risk acceleration), while the crises they generate seem to be occurring more often simultaneously (risk synchronization).

The common description of this situation as a “perfect storm” of multiple crises implies that their simultaneity is coincidental. But humanity might be confronting something far more complex and dangerous than a temporary coincidence of crises. And while scientific knowledge of the individual risks spawning these crises is deep, our understanding of causal links among risks remains shallow.

These observations raise two key questions: What causal processes might be accelerating and amplifying risks within global natural and social systems and synchronizing risks (and their concomitant crises) across these systems? And what might humanity do to mitigate or even reverse these processes?

Two trends are powerfully contributing to risk acceleration and amplification: the growth in scale of humanity’s resource consumption and pollution output beyond boundaries defining planetary resilience;[1] and the vastly greater connectivity between human systems permitting higher volume and velocity of long-distance flows of matter, energy, and information.[2]

We argue, however, that these trends, by themselves, do not fully explain this moment’s seemingly sharp amplification, acceleration, and synchronization of systemic risks. We offer a novel analytical framework to aid identification of hitherto unrecognized, complex teleconnections and self-reinforcing feedbacks among global systems. Research is urgently needed, because the ultimate result of such unrecognized processes could be a *global polycrisis*—a single, macro-crisis of interconnected, runaway failures of Earth’s vital natural and social systems that irreversibly degrades humanity’s prospects.

To date, governance of individual global systemic risks—such as pandemic disease and climate heating—has generally been inadequate, often disastrously so. Governance of the emerging risk of a polycrisis is nonexistent, largely because the national and international institutions mandated to manage systemic risks tend to operate in isolated silos.

We therefore conclude by calling for a global scientific collaboration to discern causal mechanisms that might generate a polycrisis and actionable policies to mitigate this risk. A future of cascading disasters is not inevitable: interventions could leverage global systems’ nonlinear dynamics to generate self-reinforcing “virtuous” cascades of risk reduction.

2. Systemic risks: Properties and implications for policy

The concept of "systemic risk" entered general currency after the chain reaction of failures accompanying the 2008-09 global financial crisis. Analysts outside the financial sector then broadened its application to cover "the risk or probability of breakdowns in an entire system, as opposed to breakdowns in individual parts or components."[3]

Systemic risks exhibit five properties[4]:
1. extremely complex and dynamic networks of multiple, synergistic causes and feedback loops; 2. highly nonlinear cause-effect relationships, with numerous equilibria, unpredictable tipping points, and hysteresis; 3. causal processes that cross boundaries of administrative and political units, social sectors, and scientific disciplines and that operate on multiple time scales across natural, social, and technological systems; 4. a propensity to generate "black swan" outcomes; and, for all these reasons, 5. deep uncertainty about ultimate consequences.

Complexity concepts
Complex natural and social systems exhibit *nonlinear behavior*—that is, perturbations in such systems sometimes produce disproportionately large (or small) changes in system behavior. An important source of nonlinearity is the existence of *multiple stable states* or *equilibria* that are separated by *thresholds*. A system can flip from one equilibrium to another (a *critical transition* or *tipping event*) when *feedbacks* in key processes that sustain system equilibrium shift from *negative* to *positive*—i.e., from self-dampening to self-reinforcing causal loops. Tipping events may result from interactions between adjacent systems and may be

These properties lead to risk underestimation. Complex causation and nonlinearity make assessing cause-effect links difficult; risk managers must estimate not only impacts of countless small changes within a system but also of changes in functionally connected systems. Tipping points and hysteresis make trial-and-error learning ineffective; a maladaptive behavior can generate benefits until a threshold is crossed, at which point costs are unavoidable, damage irreversible, and any learning too late. Ineffective learning then lowers the public's willingness to accept costs to lessen risk. Because systemic risks transcend administrative, social, and scientific boundaries, they often exceed managers' professional expertise and are consequently downplayed or even ignored. Also, these risks' tendency to affect multiple administrative and political domains encourages actors to free ride on others' investments in risk mitigation. Finally, deep uncertainty fosters competing policy prescriptions, aggravating a pernicious loss of trust in governments' problem-solving capacity.

In response, some experts have advised that traditional state-centric risk management—involving hierarchically organized agencies focused on discrete risks—should give way to multi-level approaches where risk governance is assigned to multiple agencies with overlapping jurisdictions.[5] Diversity helps match the social and administrative levels of risk management with the system levels at which risk operates (following the principle of subsidiarity); it can also improve resilience, experimentation, and learning. But it raises the costs of decision making, and by encouraging managers to shift responsibility from one agency to the next, it fragments risk governance and reduces accountability.

Governance of systemic risks must reconcile two fundamental tensions. First, it requires great disciplinary expertise; yet a risk cannot be fully grasped without broad knowledge of the risks' links with other systems. The need for both can overwhelm both private risk-management organizations and public risk governance. And second, development and enforcement of risk regulations demands focused, decisive, and consistent leadership over extended periods; yet without effective public learning about the underlying causes of risk, leaders may not have the political support to stay in office long enough.

These governance challenges cannot be addressed without far better understanding of global systems' evolving complexity. New methods to facilitate this understanding include World-Earth modeling that gauges resilience to black swan scenarios,[6] morphological-permutation studies (including cross-impact balance assessment),[7] and reverse stress testing that traces the impacts of potential interventions.[8]

3. Analysis of interaction

Among the best assessments of the connections among global systemic risks is a 2020 report by the research consortium Future Earth.[9] The authors analyzed scientists' perceptions of casual links among 30 specified global risks, identifying a subset of five strongly connected "core" risks likely to produce synergistic effects (climate change, extreme weather, biodiversity loss, food crises, and water crises) and another five closely associated with those in the core (involuntary migration, social instability, national governance, regional or global governance, and manmade disasters). The study did not explore the precise mechanisms of interaction among risks, although when asked what other risks deserve close attention, many respondents mentioned "failing to take into account feedbacks across systems."

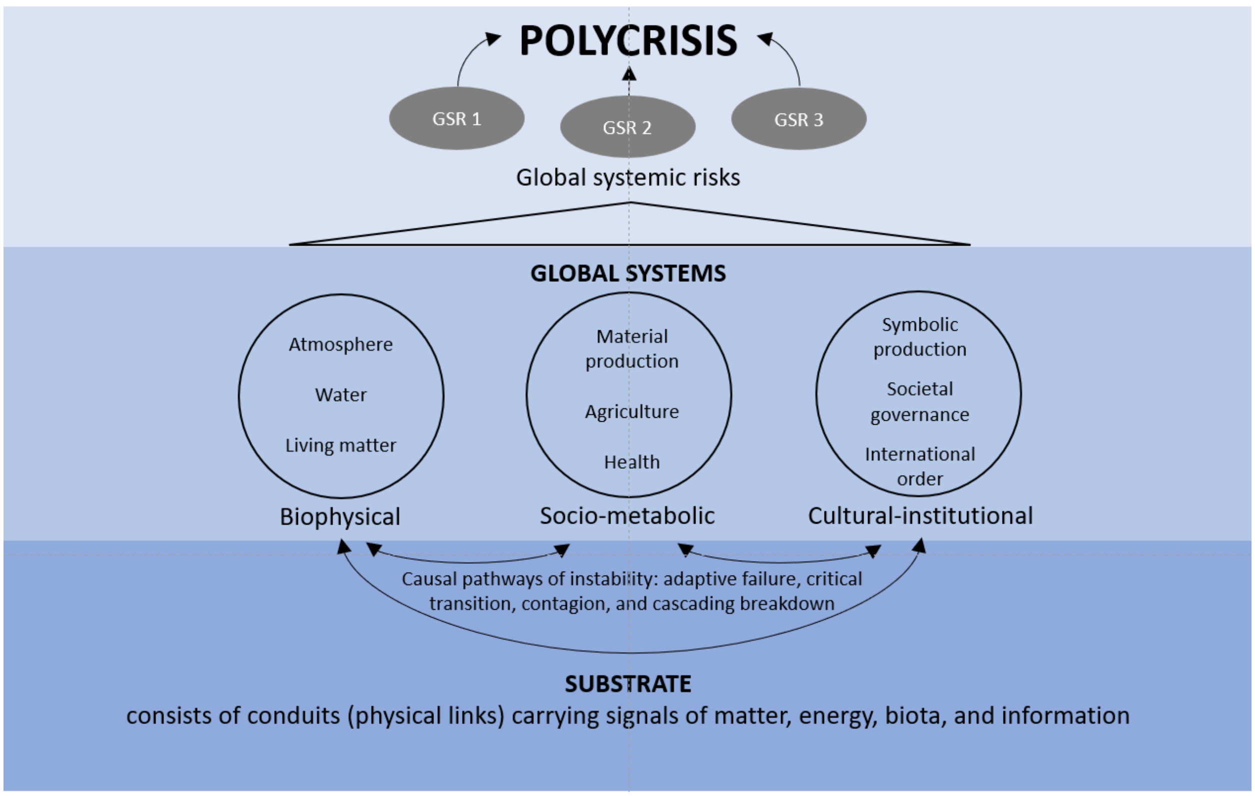
While invaluable, this and similar recent research[10] prepares humanity inadequately for the possibility of a polycrisis. We need a better grasp of 1. the underlying mechanisms that currently link (or could link) different global systemic risks, 2. how humanity might leverage the nonlinear dynamics of global systems for rapid, positive change, and 3. improved modes of governance of both global systemic risks and mitigative interventions. To aid research in this direction and guide hypothesis development, we propose a four-part framework of concepts and propositions (Figure 1).

First, we distinguish conceptually between nine global systems in three macro-categories encompassing natural, technological, and social phenomena: biophysical systems of atmosphere, water, and living matter; socio-metabolic systems of material (including industrial) production, agriculture, and health; and cultural-institutional systems of symbolic production (providing meaning, legitimacy, and coherence), societal governance, and international order. Second, we propose that positive feedbacks are significantly amplifying and accelerating systemic risks within these nine systems and synchronizing crises across them.

Research on the causal dynamics of complex systems shows that at least four distinct mechanisms can generate the nonlinear instabilities we currently observe in global systems: 1. adaptive failure when a system's stabilizing negative feedbacks are weakened or overloaded;[11] 2. critical transitions between systemic equilibria;[12] 3. contagion, as a pathogenic organism, idea, or technology jumps from node to node in a network;[13] and 4. cascading breakdown when an individual node or link's failure propagates via a system's structural interdependencies.[14] These mechanisms are not mutually exclusive and indeed may operate in combination or sequentially.

Growth in scale and connectivity of human activity likely amplifies and accelerates all four mechanisms' operation within and among global systems. But greater scale and connectivity by themselves appear insufficient explanations of today's emerging multiplicity and especially synchronization of crises.[15] As intuited by the respondents to the Future Earth survey, something else seems to be happening, and we argue the additional factor is a proliferation of positive (self-reinforcing) feedbacks.

Figure 1: Proposed analytical framework

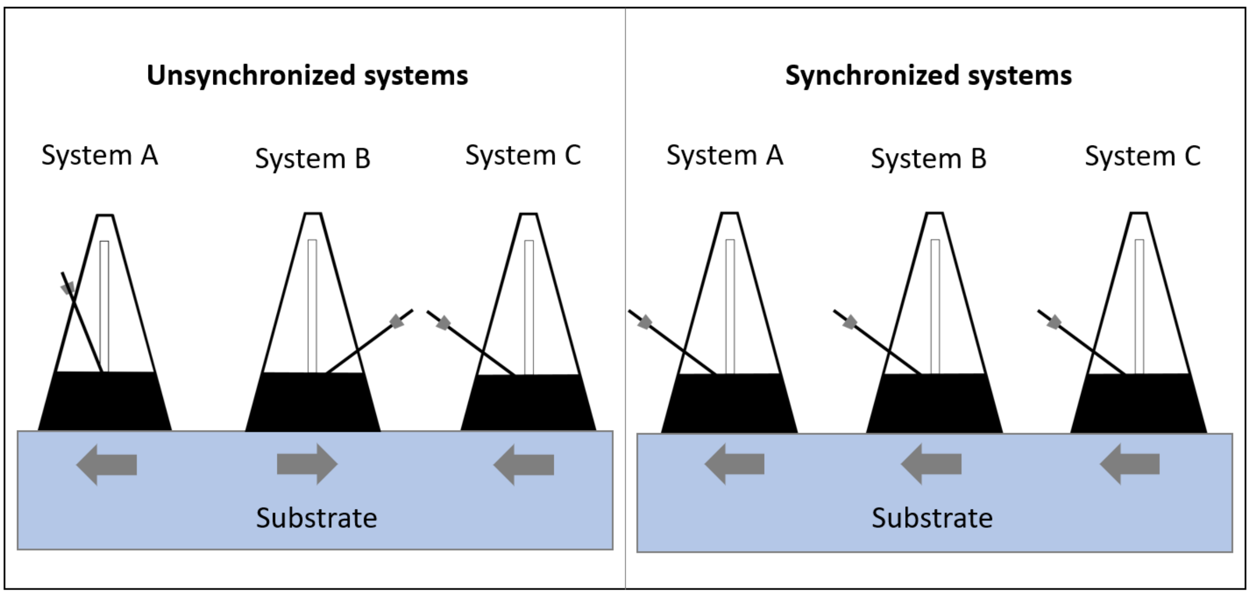


Some of these positive feedbacks are scientifically recognized and understood—the Arctic's ice-albedo feedback, for example—but many are not, and these "invisible" feedbacks can link multiple human-Earth systems.[16] For instance, extreme weather caused by climate change exacerbates economic disparities within and across societies (because of differential adaptive capabilities). These disparities intensify grievances within societies and stimulate mass migration between societies, both strengthening populist nationalism that in turn weakens global emissions governance, allowing the climate problem to further worsen. This feedback involves all three system macro-categories (biophysical, socio-metabolic, and cultural-institutional); it amplifies and accelerates the first mechanism above (by weakening the governance negative feedback); and although substantially unrecognized, it may already be having major global consequences.

Third, researchers can better study these less visible processes, we argue, by conceptually distinguishing between global systems themselves and the "substrate" that creates pathways for operation of causal mechanisms (like the four above) between these systems.

A real-world analogy shows how a substrate can facilitate invisible interactions. Randomly ticking metronomes will quickly synchronize their oscillations if placed close together on a lightweight platform that allows some lateral movement (Figure 2). The platform is the causal substrate; its lateral movement permits communication of kinetic energy between the individual systems, the metronomes. As more metronomes become synchronized, the energy communicated becomes stronger, encouraging synchronization of additional metronomes—a positive feedback that an untrained observer cannot see.

Figure 2: Systems and substrate

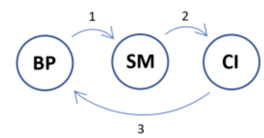
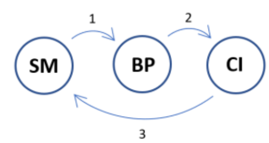
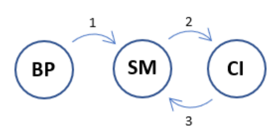
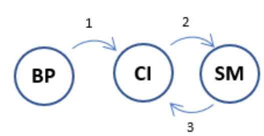


The above analogy permits, fourth, a further useful distinction between the substrate's "conduits" and "signals" that together amplify interactions between systems. The conduits are the physical links (the platform in the metronome analogy) that carry the signals (the kinetic energy transferred by the platform). In today's world, examples of conduits between global systems are container freight transportation networks, fiber optic and satellite communication links, server farms that support the Web, oil and gas pipelines, and the entire suite of technologies sustaining airline transportation.

The signals these conduits carry come in four general types: matter, energy, biota, and social information (with the latter including forms of money, expressions of group identity, and applications of social power). In the case of the COVID-19 pandemic, for example, more than zoonosis was necessary: the biotic "signal" of the novel SARS-CoV-2 virus had to be carried by the "conduits" of global trade, food exports, and air travel. Conduits and signals combine in many ways and, although generally components of global systems themselves, are distinguished by their functional roles as carriers of causal communication between systems.

Table 1 uses this framework to present four illustrative hypotheses explaining how positive feedbacks might already be amplifying, accelerating, and synchronizing global systemic risks or might do so in coming years.

Table 1: Hypotheses illustrating potential positive feedbacks among global systemic risks

Hypothesis	Principal systems implicated*	Key causal mechanism(s)	Positive feedback*
Causal processes that could already be operating			
Pandemic-caused economic dislocations generate grievances that, when amplified by digitalized disinformation, strengthen populist nationalism, thus weakening international public health cooperation and, in turn, worsening the pandemic.	BP: living matter; SM: health, material production; CI: symbolic production, international order.	Contagion (of pathogenic organism and idea); adaptive failure (of international public health system).	
Economic inequality between countries encourages cross-border migration that stimulates a shift to anti-globalization ideologies, hardens borders to migration and trade, and reduces development assistance, further exacerbating interstate economic inequality.	SM: material production, agriculture; BP: living matter; CI: symbolic production, international order	Critical transition (in economic ideology and policy)	
Causal processes that could operate in the future			
Extreme weather combines with regional water scarcity and cropland degradation to cause simultaneous breadbasket failures that trigger global food-price inflation, civil violence, geopolitical instability, and national hoarding of food, further amplifying crises of food supply.	BP: atmosphere, water, living matter; SM: agriculture; CI: societal governance, international order	Critical transition (in global climate-food production system); cascading breakdown (of global food economy)	
Sequential climate shocks encourage the spread of nihilistic worldviews, causing a collapse in fertility and economic investment that reinforces nihilism.	BP: atmosphere, water; CI: symbolic production; SM: health, material production.	Contagion (of pathogenic idea); cascading breakdown (of economy, from collapse in demand)	
*BP: biophysical; SM: socio-metabolic; CI: cultural-institutional.			

4. Research collaboration

The COVID-19 pandemic has raised awareness of humanity's escalating vulnerability to crises. "Business as usual," says United Nations Secretary General António Guterres, "could result in breakdown of the global order, into a world of perpetual crisis and winner-takes-all."[17] Researchers around the world are racing to understand systemic risks and possible responses. But they are not optimally communicating or cooperating, producing incommensurability across research programs, poor scientific cumulation and, ultimately, inadequate understanding of risks and their governance.

We propose therefore a worldwide scientific collaboration focused on the research program outlined here. It would consist of institutes dedicated, first, to studying mechanisms that are amplifying, accelerating, and synchronizing global systemic risks and, second, to specifying potential high-leverage interventions to "tip" human societies along more positive pathways.

The consortium would connect and strengthen existing research groups through a worldwide project to elaborate a generalized Global Systems Science;[10] and it would act as the international scientific complement to the Secretary General's proposed UN Futures Lab, which would integrate all humanity's "work around forecasting, megatrends and risks."[17] Given the urgency of humanity's situation, establishing such a global research program seems prudent. Failing to do so seems foolhardy.

Notes

[1] W. Steffan *et al*., Planetary Boundaries: Guiding Human Development on a Changing Planet. *Science* **347** (6223), 1259855 (2015). https://doi.org/10.1126/science.1259855.

[2] W. Steffen *et al*., The trajectory of the Anthropocene: the great acceleration. *The Anthropocene Review* **2** (1), 81-98 (2015). https://doi.org/10.1177/2053019614564785.

[3] G. Kaufman, K. E. Scott, What is systemic risk, and do bank regulators retard or contribute to It? *The Independent Review* 7 (3), 371–391 (2003). https://www.independent.org/pdf/tir/tir_07_3_scott.pdf.

[4] O. Renn *et al*., Things are Different Today: The Challenge of Global Systemic Risks. *Journal of Risk Research* 22 (4), 401-415 (2019). https://doi.org/10.1080/13669877.2017.1409252.

[5] International Risk Governance Center (IRGC), "IRGC Guidelines for the Governance of Systemic Risks" (Lausanne: International Risk Governance Center, 2018). https://doi.org/10.5075/epfl-irgc-257279

[6] J. F. Donges *et al.*, Earth system modeling with endogenous and dynamic human societies: The copan:CORE open World-Earth modeling framework. *Earth System Dynamics* **11**, 395–413 (2020). https://doi.org/10.5194/esd-11-395-2020.

[7] W. Weimer-Jehle *et al*., Socio-technical energy scenarios: state-of-the-art and CIB-based approaches. *Climatic Change* **162**, 1723–1741 (2020). https://doi.org/10.1007/s10584-020-02680-y.

[8] J. Skoglund, W. Chen, Risk contributions, information and reverse stress testing. *The Journal of Risk Model Validation* **3** (2), 61-77 (2009). https://doi.org/10.21314/JRMV.2009.041.

[9] Future Earth. "Risks Perceptions Report 2020: First Edition" (Future Earth, 2020). https://futureearth.org/wp-content/uploads/2020/02/RPR_2020_Report.pdf.

[10] D. Helbing, Globally networked risks and how to respond. *Nature* **497,** 51–59 (2013). https://doi.org/10.1038/nature12047.

[11] F. S. Chapin *et al*., "A Framework for Understanding Change" in *Principles of Ecosystem Stewardship* (Springer, New York, 2009), pp. 3-28. https://doi.org/10.1007/978-0-387-73033-2_1.

[12] M. Scheffer, *Critical Transitions in Nature and Society* (Princeton University Press, Princeton, NJ., 2009).

[13] R. Pastor-Satorras *et al*., Epidemic processes in complex networks. *Rev. Mod. Phys* **87**, 925 (2015). https://doi.org/10.1103/RevModPhys.87.925.

[14] A. Bashan *et al.*, The extreme vulnerability of interdependent spatially embedded networks. *Nature Phys* **9**, 667–672 (2013). https://doi.org/10.1038/nphys2727

[15] A. Arenas *et al.*, Synchronization in complex networks. *Physics Reports* **469**, 95-153 (2008). https://doi.org/10.1016/j.physrep.2008.09.002.

[16] J.C.Rocha *et al.*, Cascading regime shifts within and across scales. *Science* **362**, 1379-1383 (2018). https://doi.org/10.1126/science.aat7850.

[17] A. Guterres, Secretary-General's remarks to the General Assembly presenting "Our Common Agenda" (United Nations, 10 September 2021). https://www.un.org/sg/en/node/258971.