Dynamics of the polycrisis: temporal trends, spatial distribution and co-occurrences of national shocks (1970-2019)

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Non-technical summary

In response to the concerns of a growing number of crises, we trace the temporal trends, distribution and co-occurrences of shocks—sudden events with noticeable impacts—on 175 countries from 1970 to 2019. Our analysis shows that shocks have not evolved uniformly over time and space: after becoming more co-occurring between 1970 and 2000, they then showed a regionally-dependent shift in patterns. Our results highlight that regional differentiation is not incidental but constitutive of polycrisis dynamics, and that any effort to theorize, anticipate, or navigate polycrisis must account for this spatial heterogeneity.

Technical summary

Polycrisis has emerged as a new property of the Anthropocene. Although sector-specific studies offer insights into the changing frequency and intensity of these disruptions, a comprehensive analysis remains absent, limiting a more integrated understanding of the polycrisis phenomenon. Addressing this gap, we develop and analyse a harmonized database capturing the occurrence of six categories of shocks (climatic, geophysical, ecological, economic, technological, and conflict-related) across 175 countries between 1970 and 2019. Our analysis reveals a significant rise in shock co-occurrences until 2000, particularly at the intersection of conflict, climate, and technological disruptions. After 2000, co-occurrence began plateauing or declining in all regions, yet at different levels. Our findings highlight the importance of a regionalized and typologically nuanced approach to understanding polycrisis. Our work also paves the way to an integration of polycrisis theory and multi-hazard methodologies for developing more effective and anticipatory polycrisis management.

Social media summary

Dynamics of the polycrisis reveal regional differences, with a possible shift in the interaction of shocks from 2000.

Keywords

Polycrisis; Shocks; Biosphere; Anthropocene; Social-Ecological Systems; Resilience

1. Introduction

The growing intensification of changes on social-ecological systems has dramatically changed the Earth's biosphere (Folke et al., 2021). The contemporary understanding of 'crisis' has accordingly evolved from a series of isolated discrete events to a prolonged and volatile turmoil unfolding across multiple scales and dimensions (Revault d'Allones, 2016). The global financial crisis in 2007/2008, COVID-19 pandemic, the Russian invasion of Ukraine, three events that have severely impacted our social, energy, and economic systems through their rapid and far-reaching spread, are prime examples of this shift. What's more, crises now seem to interweave and amplify one another. This complex situation has led scholars, practitioners, and policymakers to increasingly use the concept of "polycrisis". Defined as the convergence of crises across multiple systems, leading to greater harm than each crisis would cause in isolation (Morrin & Kern, 1993; Lawrence et al., 2024a; Mark et al., 2024), the polycrisis questions the current notion of risk (Keys et al., 2019; Wassénius & Crona, 2022) and calls for a change of paradigm in scientific theory (Jacobs, 2024), methods (Hopper et al., 2023) and models (Koasidis et al., 2023).

Characterizing polycrisis dynamics, by essence complex and nonlinear, is the first step in that direction. Yet, and as highlighted by the polycrisis community in its Research and Action Roadmap (Lawrence et al., 2024b), it requires navigating across space and time, as crises have become capable of spreading across sectors and scales. To fill this gap, we here adopt a social-ecological systems (SES) approach to decompose polycrisis dynamics into two interrelated processes: creeping changes—slow onset of incremental changes—and shocks—sudden events with noticeable impacts. Leaving the exploration of creeping changes for future work, we map out the temporal trends, distribution and co-occurrences of shocks across 175 countries, from 1970 to 2019. We believe that this analysis, being done simultaneously but with a different methodology (only using one dataset of shocks, but a longer time frame of study) by Mark et al. (2024b), is a starting point to unpack and better understand the causal architecture of the polycrisis, as previously suggested by Homer-Dixon et al. (2015). Specifically, we contend that our work should serve as a basis for identifying response diversity strategies (Walker et al., 2023).

This paper is structured as follows. Section 2 reviews the existing literature on shocks, both theoretically and empirically. Section 3 presents the materials, data and methods used to build the database of shocks. Section 4 discusses the obtained results in terms of temporal trends, distribution and co-occurrences of shocks, and underlines limitations of the study while suggesting perspectives for future research. Section 5 concludes.

2. Literature review

2.1. Polycrisis processes: creeping changes and shocks

The thin layer of the Earth hosting life, the biosphere, comprises complex adaptive social–ecological systems (SES) characterized by feedbacks across multiple interlinked scales that amplify or dampen change (Fischer et al., 2015). SES are currently subject to a wide range of pressures, taking the form of continuous long-term stress (“creeping changes”), or events of rapid onset and duration with noticeable impact (“shocks”).

Creeping changes refer to slowly evolving variables that threaten widely shared societal values or life-sustaining systems, and which unfolds over extended periods and across various locations (Boin, Ekengren, & Rhinard, 2021). They are characterized by a lack of clear onset, long incubation periods, often ambiguous or insufficient responses, and are typically foreshadowed by precursor events. Antimicrobial resistance exemplifies a creeping change, with the burden increasing gradually and often unnoticed across nearly all critical pathogen–drug combinations between 1990 and 2021, quietly escalating into a major threat to public health and healthcare systems (Naghavi et al., 2021). Creeping changes create locked-in trajectories, also referred to as evolutionary “Anthropocene Traps” (Søgaard Jørgensen et al., 2023), which gradually erode resilience, weaken adaptive capacity, and increase hidden vulnerabilities (Miller et al., 2010).

Shocks refer to abrupt, often nonlinear disturbances that rapidly disrupt a system’s stability (Miller et al., 2010). Examples of shocks include coral bleaching events in the Great Barrier Reef, large-scale wildfires such as those in Australia in 2019-2020, sudden transmission of SARS disease, etc. Shocks significantly disrupt SES, triggering reorganization, adaptation, and even long-term transformation.

These events often damage critical ecosystem services, leading to direct impacts on human livelihoods and wellbeing while increasing vulnerability to future disturbances. For instance, extreme weather can not only cause immediate losses but also degrade the ecosystem's capacity to respond—by depleting resources, breaking key social or ecological networks, and weakening institutional support. Such situations demand urgent action to strengthen system resilience. However, responses to shocks may prove inadequate or even harmful, leading adaptation to be maladaptive and locking systems into trap situations (Magnan et al., 2016). A stark example is the post-tsunami cleanup in Sri Lanka in 2004, which accelerated salinity intrusion into freshwater aquifers, leaving communities to rely on water deliveries and low groundwater quality for months to over a year (Renaud et al., 2010).

Creeping changes and shocks interact and, through direct or indirect mechanisms, destabilize SES systems, with the potential of bringing them to cross thresholds upon which their behaviours change radically. For instance, gradual increases in sea surface temperature are pushing fish towards higher latitudes, while sudden market pressures can trigger overfishing in some regions. Together, these factors can drive fish stocks to ecological tipping points, beyond which their populations may collapse (Cottrell et al., 2019; Cooper et al., 2020; Free et al., 2020).

2.2. Current research frontiers on shocks

Research on shocks is rich, rapidly increasing and demonstrates a wide array of approaches. On a theoretical level, considerable attention has been devoted to several categories of shocks: natural hazards (Ward et al., 2020), conflicts (Diehl et al., 2019), infectious diseases (Baker et al., 2021), and food systems, particularly fisheries (Hodbod & Eakin, 2015; Kaplan-Hallam et al., 2017). Significant progress has also been made in recent years toward unpacking the interrelations among different types of shocks, both within categories (such as multiple interacting hazards; Renaud et al., 2010; Wang et al., 2020) and across domains—for instance, the links between climate change and conflicts (Koubi, 2019)..

On an empirical note, several attempts have been carried out to map shocks and their co-occurrences. Biggs et al. (2015), for instance, assess the evolution of regime shifts, impacts, key drivers, underlying feedbacks, and management options over 300 case studies. Cottrell et al. (2019) build on the work of Gephart et al. (2017) to estimate the frequency of food production shocks (crop, livestock, aquaculture and fisheries) and show a notable increase in all major sectors across land and sea over the past 53 years. Fisher et al. (2021) evaluate how a specific climate shock (marine heatwave) modifies flows of users between fishery resources using a network analysis. Carper et al. (2021) quantify shock-response assessment regime over a period of 30 years (1989–2019) in the Rechna Doab basin (northeastern Pakistan). d'Errico et al. (2023) combine several datasets to study how different shocks (natural disaster, livelihood-related, health shocks) reduce households' resilience between 2014 and 2020. Hoyer et al. (2023, 2024) developed the Crisis Database (CrisisDB), comprising 168 societal crises (population decline or collapse, downward mobility or extermination of elites, uprisings, civil war, state fragmentation, external conquest, ruler assassination or deposition, etc.) spanning multiple time periods and regions, by systematically collecting historical information about the events characteristics. Finally, Shaban et al. (2024) analyze the extent to which contextual social-ecological conditions of entrepreneurial uncertainty, agricultural shocks, and poorly designed responses from institutions interact with tragic behaviors by farmers.

2.3. Gaps and opportunities

While research on shocks has been prolific, especially for climate, conflict, and ecological shocks, less attention has been devoted to their co-interaction in an integrated approach. A result is that empirical methods and data that help understand how components of the global system absorb, transmit and link together shocks are still missing (Kaplan-Hallam et al., 2017; Beauchamp et al., 2020; Viña & Liu, 2022). We hope that this study will contribute to fill this gap, and bridge the social-ecological systems approach with existing sectoral datasets from other communities. The rapprochement between polycrisis and the social-ecological systems approach is all the more supported by the long-standing tradition of shocks study in the latter field (Biggs et al., 2011), but also by its maturity and openness towards other approaches (Cumming & Peterson, 2017). It is further backed by the recent investigation of undesirable resilience and socio-technical lock-in (Dornelles et al., 2020), in order to make the adaptive capacity of SES to extreme changes more operational (Thonicke et al., 2020) and more suited for a conflict-prone environment (Méndez et al., 2022; Goldstein et al., 2023; Rist et al. 2024).

3. Methodology

3.1. Main stages of the research process

The approach used in this study involved five successive key stages (Fig. 1). First, we reviewed relevant literature to identify a framework of shocks (“what is a shock and what is not, in regard to Anthropocene changes”, “what categories of shocks exist in social-ecological systems”, etc.). This inductive step was carried out by the research team and allowed us to classify shocks in 6 categories depending on their core mechanism: climatic, geophysical, ecological, economic, technological, and conflict. The framework developed reflects a conceptual classification that inherently involves some degree of subjectivity, meaning that a different research team would likely have produced a distinct one. Yet, we believe this shock framework encompasses major dynamics of shocks that have been tracked and measured over the years, with limited overlap between categories. Second, we surveyed existing regional or global datasets on shocks and, relying on a set of criteria and pre-identified relevant indicators or proxy, we selected a set of six datasets (see below for further detail). Third, we standardized each one to comply with a formal and shared template, where geographical and temporal scales were reconciled with Python scripts. More specifically, we used the package country_converter (Stadler, 2017) on country data, then splitformer states into the corresponding current states (e.g. USSR before 1991) and we filtered out countries that were missing observations in at least one category (although providing a full pre-filtered dataset in the supplementary materials). Fourth, we assessed the robustness period of each dataset, identifying potential bias in each, before expressing the data in a single csv file. It has to be noted that, following our data check, the magnitude and impact of shocks (casualties, U.S. dollars, etc.) was deemed inconsistent across datasets, and as such, is not treated in the present analysis (only the number of shocks is presented). Fifth, we analysed the results, and explored the temporal trends, distribution and co-occurrences of shocks over time through statistical analysis.

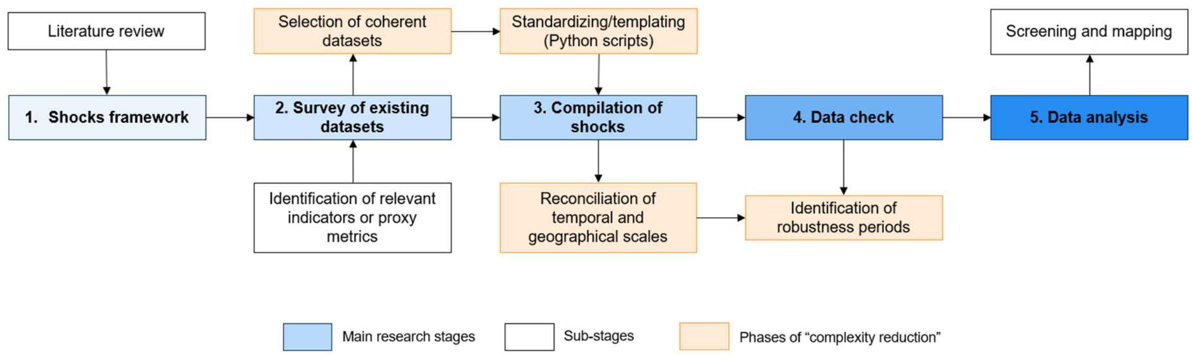

Figure 1: Main stages of the research process.

3.2. Datasets description

The six datasets collected, standardized, and compiled as well as selected indicators per shock category are presented in Table 1.

For climatic shocks, EM-DAT was selected due to its extensive coverage of shocks and prominent use in the field of natural disasters (Delforge et al., 2023). EM-DAT compiles over 26,000 disasters (10 deaths or above, 100 people affected or above, call for international assistance issued or state emergency situation declared) data from 1900 to the present day. It has been used widely, with, among others, linking to geocoded locations (Rosvold & Buhaug, 2021), infectious diseases outbreaks (Franzke & Czupryna, 2021), human displacement (Mester et al., 2023) and social-ecological variables (Nones et al., 2023). Only six types of shocks—drought, extreme temperature, flood, wet mass movement, storm, and wildfire—were classified as climatic, as they are majorly driven by climatic factors.

For geophysical shocks, we also relied on EM-DAT but extracted only a selection of disasters (earthquake, volcanic activity, dry mass movement, meteorite impact) which are considered to be mainly of geophysical origin.

For ecological shocks, we employed the dataset of Cottrell et al. (2019) for production shocks in different food sectors (i.e. crops, livestock, capture fisheries and aquaculture), and combined the Disease Outbreak News (DONs) dataset (Carlson et al., 2023) with EM-DAT for the epidemiological shocks (EM-DAT is used from 1970 to 1996 and DONs from 1996 to 2019). Reason for those two shocks to be classified together is that they mostly originate from ecological disturbances.

For economic shocks, we employed the dataset of Nguyen et al. (2022), which comprises 151 systemic banking crises, 414 currency crises and 200 sovereign debt crises. This dataset, which builds on the one of Laeven and Valencia (2020), has the advantage to be more systematic but also covers more countries over a longer period of time.

For technological shocks, we relied on EM-DAT, which comprises air shocks (e.g., plane crash), chemical spill, industrial collapse (e.g., bridge failing), miscellaneous collapse (e.g., house collapse), industrial explosion, miscellaneous explosion, industrial fire, miscellaneous fire, gas leak, industrial accident (general), miscellaneous incident (general), oil spill, poisoning (e.g., pollution of a water course), radiation, rail (e.g., train accident), road (e.g., truck accident), and water (e.g., cruise ship accident).

For conflict shocks, we used the updated version of the Global Terrorism Database (GTD) of LaFree & Dugan (2007) as well as the Uppsala Conflict Data Program (UCDP) version 24.1 of Hegre et al (2020). GTD is an open-source dataset on terrorism, which covers more than 200,000 cases of domestic and international terrorist incidents from 1970 through 2020. The UCDP is a continuously updated dataset on armed conflicts and organized violence (state-based non-state or one-sided violence) hosted by the Department of Peace and Conflict Research at Uppsala University.

Shock category	**Shocks types**	**Time coverage**	**Dataset used**	**Key reference**
Climatic	- Drought - Extreme temperature - Flood - Mass movement (wet) - Storm - Wildfire	1900 - 2023	EM-DAT	Delforge et al. (2023)
Geophysical	- Earthquake - Volcanic activity - Mass movement (dry) - Impact	1900 - 2023	EM-DAT	Delforge et al. (2023)

Ecological	- Food production shocks (crops, fisheries, aquaculture, livestock) - Infectious diseases	1961 - 2013 1900 - 2023 1996 - 2024	Cottrell et al. EM-DAT DONs	Cottrell et al. (2019) Delforge et al. (2023) Carlson et al. (2023)
Economic	- Systemic banking crisis - Currency crisis - Sovereign debt crisis	1950 - 2019	Systemic Banking Crises Database	Nguyen et al. (2022)
Technological	- Air - Chemical spill - Collapse (industrial) - Collapse (miscellaneous) - Explosion (industrial) - Explosion (miscellaneous) - Fire (industrial) - Fire (miscellaneous) - Gas leak - Industrial accident (general) - Miscellaneous incident (general) - Oil spill - Poisoning - Radiation - Rail - Road - Water	1900 - 2023	EM-DAT	Delforge et al. (2023)
Conflict	- Terrorist attacks - Interstate conflicts - Intrastate conflicts - Extrasystemic	1970 - 2021 1946 - 2023	GTD UCDP	LaFree & Dugan (2007) Hegre et al. (2020)

	conflicts			

Table 1: Indicators, time coverage and scope of the compiled datasets.

3.3. Statistical analysis

Once the shocks were compiled in a common format and single file, we carried out a statistical analysis in several steps. First, we estimated the temporal trends of the shocks by unpacking the gross number of shocks. Second, we analysed the distribution of shocks to uncover regional dynamics. However, the total number of shocks is not comparable across categories. For instance, the number of terrorist attacks recorded is two orders of magnitude greater than any other shock, thus the world total would only reflect the Conflict category. Thus, we followed a normalization process to avoid excess representation of one category over the others. The normalization consists in dividing each shock by the mean over the study period of the world total, to get a result around 1.

$$\underline{n} = mean(n_{world,y}) = \frac{\sum_{1970\leq y\leq 2019} (n_{world,y})}{|\{y|n_{world,y}\neq 0\}|}, \text{ with } n_{world,y} = \sum_{c\in Countries} n_{c,y} \quad (1)$$

As we do not record 0s in the database, the mean is computed only on non-zero values, which has the final effect of giving less weight to sparse shocks, like Meteorite impacts. We then divide by the number of shocks per category *catSize* to get similar sizes. The normalized shock is given by:

$$\hat{n}_{c,y} = \frac{n_{c,y}}{\underline{n} * catSize} \quad (2)$$

Thirdly, we analyzed the co-occurrences of shocks by summing up all pairs of shocks that appeared in a country during the same year. This allowed us to estimate the relative frequency of multi-shock occurrences. It depicts temporal co-occurrence of shocks in the same country in the same year, but does not necessarily imply an actual causation or other kind of relationship between them. More precisely, the study of co-occurrence has been done generating circos plots, where we initially segmented our data annually and then identified all unique pairs of concurrent shocks within each country. For instance, if country "A" experienced shocks "1", "2", and "3" in 1991, we would form the pair combinations "1-2", "2-3", and "1-3", indicating simultaneous occurrences. Similarly, if country "B" encountered shocks "1", "2", and "4", we would increment the count for the already identified pair "1-2" and introduce new pairs "1-4" and "2-4". This process was repeated for all countries and for each year to compile the frequencies of concurrent shock pairs. The circos plot visually represents these connections, where the thickness of the lines indicates the frequency of co-occurrence across different countries and over time.

4. Results and discussion

4.1. Temporal trends, spatial distribution and co-occurrences

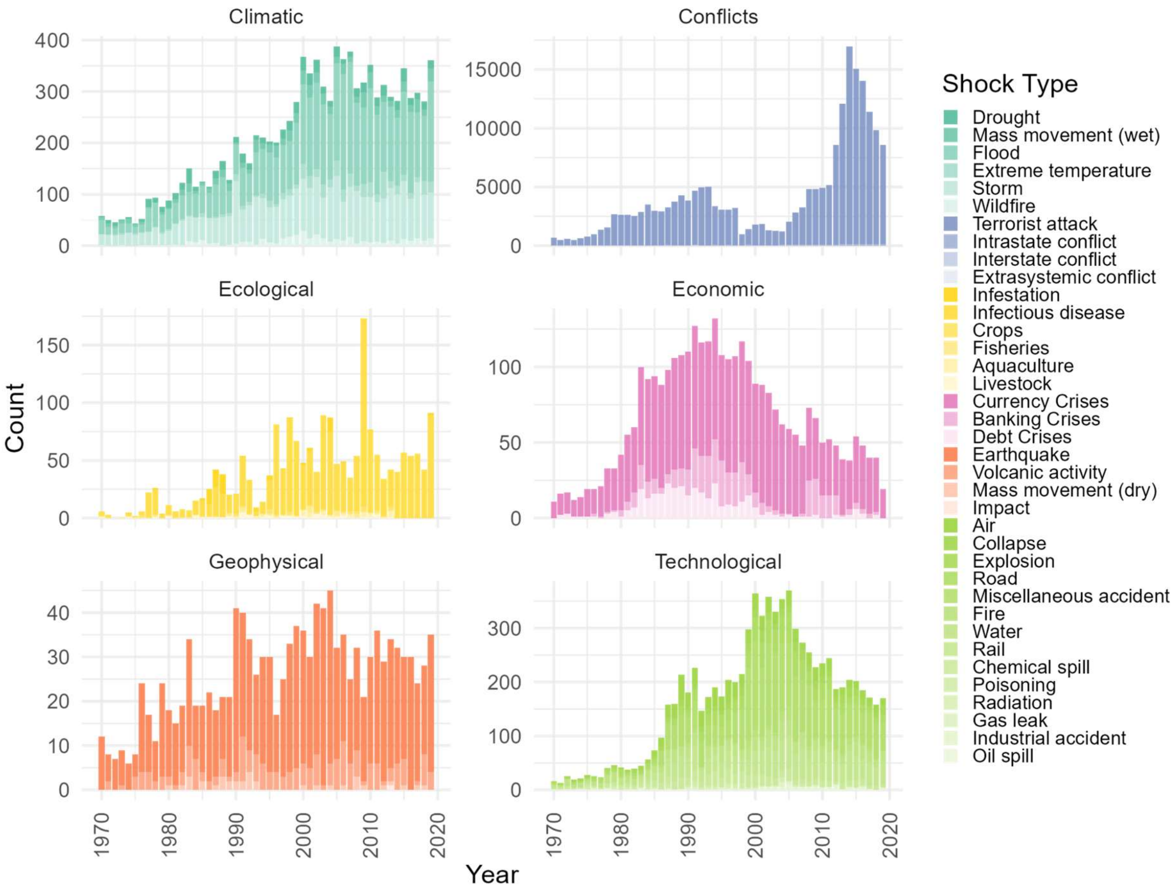

Figure 2: Number of shocks per category from 1970 to 2019, global scale. Note that food production shocks (crops, fisheries, aquaculture, livestock) data stops in 2013.

The total gross number of shocks shows different dynamics depending on the category of shock considered (Fig. 2). For example, climate-related shocks increase steadily from 1970 onwards until they reach an apparent plateau in the early 2000s, which may be linked to the more robust and systematic selection of events from that time onwards for EM-DAT (see 'Limitations and future development' section). Conflict-related shocks follow a different pattern, with a slow increase between 1970 and 1980, a rising plateau between 1980 and 1995, a decline between 1995 and 2005 before what appears to be an exponential increase from 2005 onwards followed by a strong decrease since 2010. Ecological shocks vary considerably, with a first period from 1970 to 1985 being fairly mild, before becoming increasingly severe (except the mid 1990's drop), and peaking in 2009 with almost 160 shocks. Economic shocks follow a bell-shaped curve, with a peak over 100 shocks between 1987 and 1999, and are majorly driven by currency crises. Geophysical shocks show an increasing trend from 1975 to 2000 and a stagnation after, with important variations in between years. Technological shocks seem to follow a step function with a first stable period around 25 shocks per year from 1970 to 1980, a higher step around 150 shocks from 1985 to 2000, and an even higher step from 2000 to 2006 around 300 shocks, before falling to approximately 200 shocks per year in the 2010's.

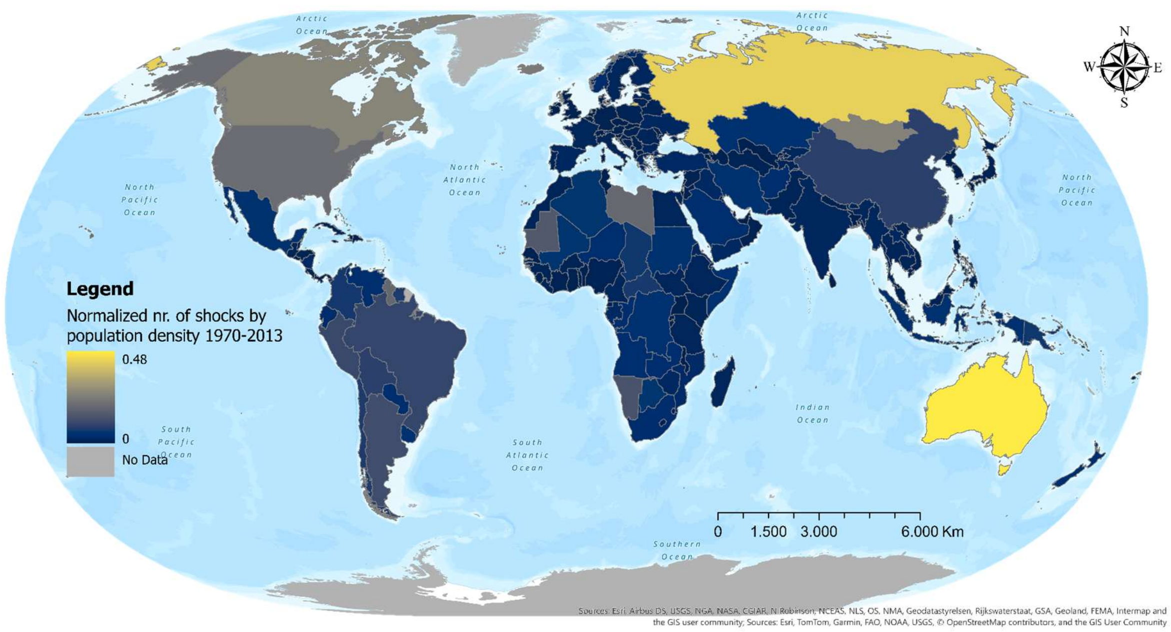

Figure 3. Normalized number of shocks per country's population density from 1970-2019 including six categories: climatic, geophysical, ecological, economic, technological and conflict. Higher values (lighter colors) mean lower incidence of shocks.

In terms of geographical distribution, our analysis reveals a pronounced unevenness in the incidence of normalized shocks relative to population density (Fig. 3). Patterns indicate that the number of normalized shocks to population density appears highest in countries that are geographically expansive yet sparsely populated (e.g., Russia, Australia). In such contexts, the total number of shocks—once normalized—becomes comparatively small relative to the overall land area and population distribution, resulting in higher ratio values (i.e., fewer shocks per unit of population density). By contrast, regions with denser populations (such as much of Europe and parts of Asia) display lower ratio values, signifying that shocks occur more frequently when measured against the size and density of the population. Intermediate values in North America, Libya, Mauritania, Namibia, and Mongolia likely arise from the interplay of moderately low population densities, significant land masses, and region-specific factors (including economic conditions and reporting practices). Meanwhile, lower ratios in parts of Africa and South America may be associated with greater concentrations of shocks in relation to the population, although underreporting and uneven data coverage could also influence these figures.

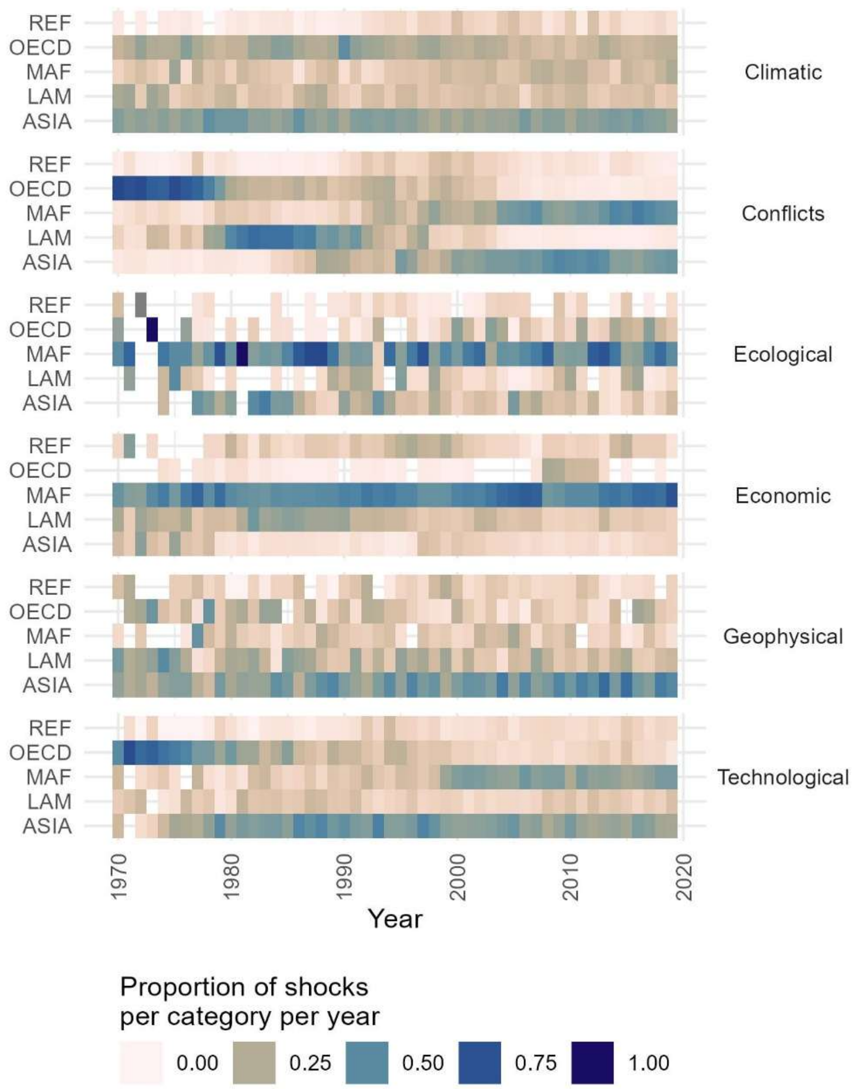

Figure 4. The share of shocks per category per year in each region. REF = the reforming economies of Eastern Europe and the former Soviet Union , OECD = The Organisation for Economic Co-operation and Development 90 countries and the European Union member states and candidates, MAF = the Middle East and Africa, LAM = Latin America and the Caribbean, ASIA = Asian countries except the Middle East, Japan and the former Soviet Union states.

Over time, the distribution of shocks reveals disparate dynamics between regions (Fig. 4). Climatic shocks, for instance, affect mostly OECD and Asian countries. Conflicts seem at first mostly based in OECD (1970 - 1980), before being mostly present in Latin America and the Caribbean (1980 - 1990) and then in MAF and Asia (2000 - 2019), simultaneously. Ecological shocks appear majorly in the

Middle East and Africa from 1970 to 2019, and to a lesser extent in Asia from 1975 to 1985. Economic shocks are driven by MAF, and seem absent in OECD countries until the Global Financial Crisis (2007 - 2008). Geophysical shocks emerge in every region, but Asian countries gradually take over as the leading one. Technological shocks concern first OECD countries (1970 - 1980) before Asia takes the lead (1980 - 2000) and until MAF countries reach a similar proportion of shocks per year.

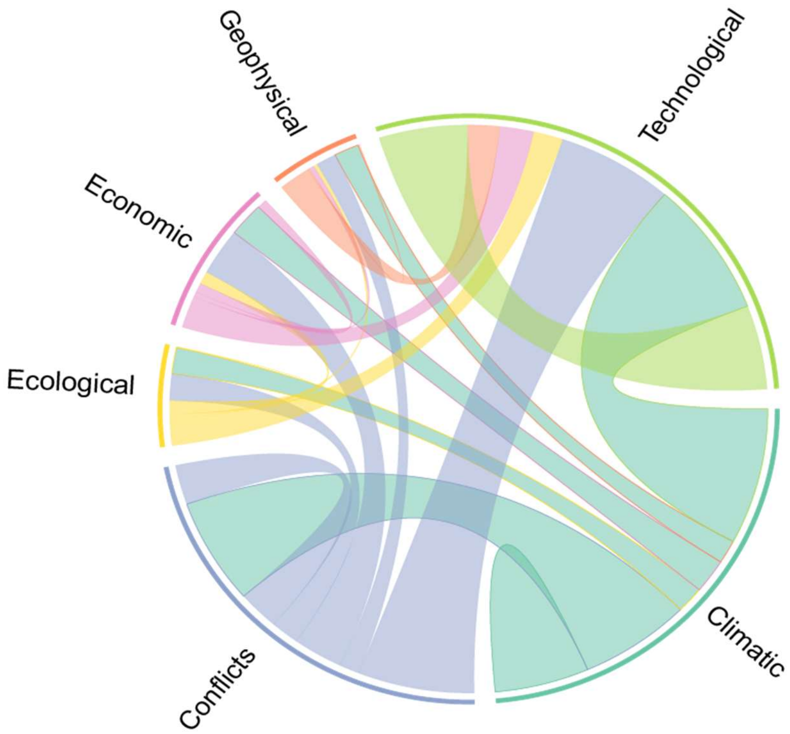

Figure 5: Multi-shock Circos plot per shock category (1970 - 2019). Connections between coloured segments denote shock interactions, with line thickness indicating the relative frequency of multi-shock occurrences.

Figure 5 shows the co-occurrences among shocks categories, revealing those that are more co-occurring to others. Four most frequent pairs appear: Climatic - Technologic, Climatic - Conflicts, Conflicts - Technological and Technological - Technological. We also observe that while many of the shocks are intra-category (e.g. intra-state conflict and terrorist attack), there are many connections across categories (e.g. infectious disease and drought). This interconnectedness depicts only temporal co-occurrence of shocks in the same country in the same year, but does not necessarily imply an actual causation or other kind of relationship between them.

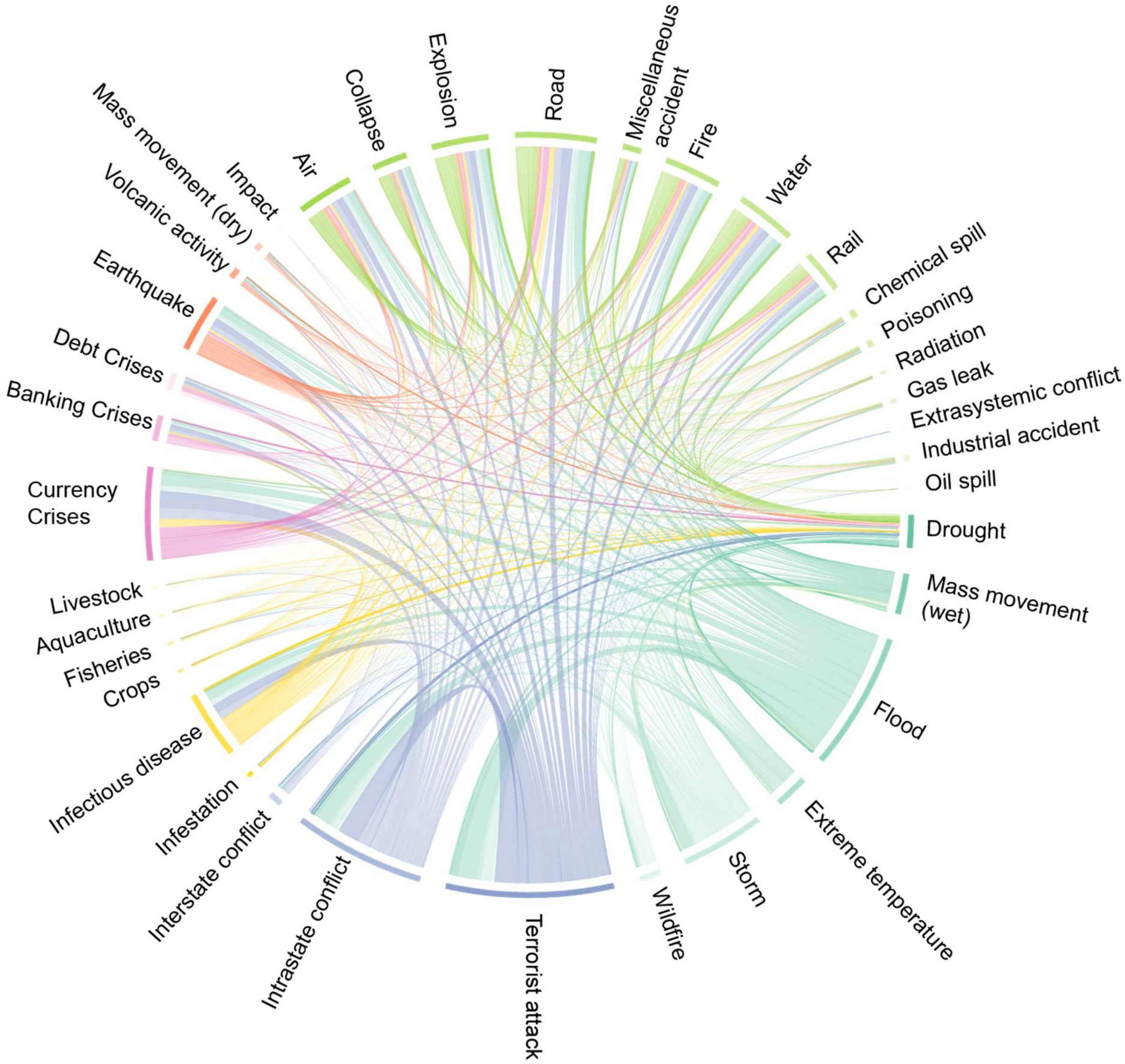

Figure 6: Multi-shock Circos plot per shock type (1970 - 2019). Connections between colored segments denote shock interactions, with line thickness indicating the relative frequency of multi-shock occurrences.

Figure 6 shows the co-occurrences among shocks, revealing those types of shocks that are more co-occurring to others, like floods, terrorist attacks, intrastate conflicts, and currency crises. If no pair of shock types appears to be disproportionately represented, three most frequent pairs are still found in the co-occurrence analysis: Terrorist attack-Intrastate conflict, Flood-Terrorist attack, and Terrorist attack-Currency Crises, being terrorist attacks always present in these observations of co-occurrences as it is also the type of shock with the highest number of observations. The top three most frequent observations not accounting for any pair that contained terrorist attacks are: Flood-Currency Crises; Intrastate conflict-Currency Crises; and Flood-Storm.

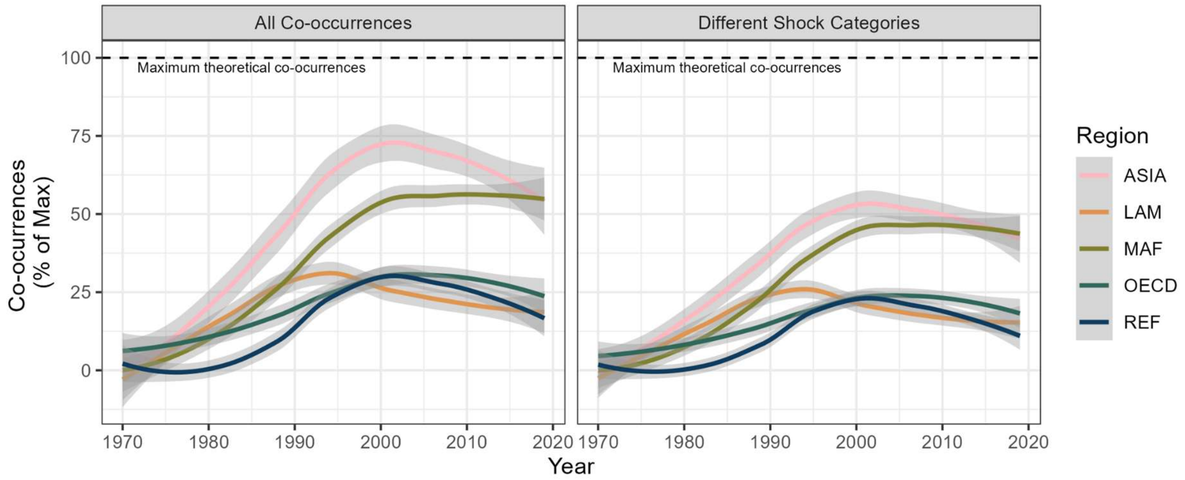

Figure 7: Co-occurrence of shocks by region and over time, for all shocks and all categories (left), for shocks in different categories and all categories (right). Estimates for co-occurrence of shocks in different categories shows the sum of synchronous shocks that belong to the same category (e.g., the pair Flood-Mass Movement (wet) would not be accounted for as both shocks belong to different categories). REF = the reforming economies of Eastern Europe and the former Soviet Union, OECD = The Organisation for Economic Co-operation and Development 90 countries and the European Union member states and candidates, MAF = the Middle East and Africa, LAM = Latin America and the Caribbean, ASIA = Asian countries except for the Middle East, Japan, and the former Soviet Union states. The theoretical maximum for co-occurrences corresponds to a state in which all countries experience one of every shock type per year.

The co-occurrence of shocks per region over time (Fig. 7, left) shows that shocks have become more co-occurring from 1970 to 2000 globally, with an average increase of 7% per decade. Yet, various dynamics can be observed. The ASIA and MAF regions, for instance, undergo a rapid and significant increase in co-occurrence, nearing 75% and 50% of the theoretical maximum in 2000, respectively. In contrast, co-occurrences in the LAM, OECD and REF countries are increasing more slowly (particularly REF, which only emerged late from 1980) and peak at a lower magnitude (30% of the theoretical maximum). Trends after 2000 remain divided in two groups of regions (high co-occurrence for Asia-MAF, and medium for LAM-OECD-REF), with co-occurrence falling steadily in all regions, except MAF where it stagnated. We believe that these trends can be explained by a more systematic reporting of events after 2000 in EM-DAT, as supported among others by Joshi et al. (2024b), which would imply that a higher number of events is screened and hence co-occurrence would stagnate. Moreover, we find the co-occurrence of shocks between categories appears less numerous than the co-occurrences between shocks but still follows similar trends (Fig. 7, right). This indicates that shocks are not also co-occurring within their category, but also outside their category.

4.2. Implications for polycrisis theory and practice

Our findings make several contributions to the field of polycrisis. Most centrally, this study challenges a prevailing assumption—found in works such as Jacobs (2024)—that shocks have been growing steadily more numerous and co-occurring over time. While our results confirm a clear rise in co-occurrence between 1970 and 2000, they also reveal a subsequent plateau and, crucially, divergence in regional trajectories. Much of the polycrisis literature continues to adopt a global or Euro-Atlantic analytic frame (Zeitlin et al., 2019; Nicoli & Zeitlin, 2024), often overlooking how crises manifest unevenly across space. Our findings suggest that regional differentiation is not incidental but constitutive of polycrisis dynamics, and that any effort to theorize, anticipate, or navigate polycrisis must account for this spatial heterogeneity. Additionally, our analysis highlights the need to move beyond viewing shocks as a singular or undifferentiated phenomenon. Distinct categories—such as climatic, technological, and conflict-related shocks—tend to cluster in patterned, context-specific ways, highlighting the need for a more refined typology of shock interrelations within polycrisis.

This work also intersects with and extends the field of multi-hazard research. Like polycrisis, multi-hazard study engages with the interplay of interrelated shocks. Yet its focus on physical hazards has emphasized cascading or compound effects, within sector-specific or localized settings (Ward et al., 2022). Our study complements recent methodological advances—such as those by Lee et al. (2024) and Jäger et al. (2024)—by offering an empirically grounded analysis that encompasses a broader array of shocks. This study thus helps bridge the conceptual divide between multi-hazard and polycrisis approaches and points toward the common development of a polycrisis management paradigm—one that builds on the institutional knowledge and practice-based insights of the multi-hazard community, while embracing the polycrisis perspective for its ability to capture systemic and cross-sectoral feedbacks. That way, ongoing challenges identified in the practice and implementation of multi-hazard risk reduction—such as limited cross-sectoral coordination, data gaps, and insufficient attention to long-term, systemic drivers of vulnerability (Trogrlić et al., 2024)—could be mitigated.

4.3. Limitations and future developments

The present study is limited both by its method and the data it relies on. Methodologically, the decision to normalize shocks was made to ensure a comparable number of shocks over all categories. We here decided to rely on a simple normalization, which we believe is the most explicit and as such, most understandable by a wide range of readers, yet there are plethora of available methods and indices that can be explored in the future with the dataset. In addition, the grouping of countries in REF, OECD, MAF, LAM and ASIA regions is rich from a socioeconomic perspective (in terms of colonizing history, power structures, cultural values, etc.), but is debatable from a biophysical (temperature, precipitation etc.) perspective. Moreover, because the current version of the dataset aggregates shocks at the national level, transboundary events—such as regional floods or droughts—may be double-counted. This limitation, widely recognized in the hazards literature (Rosvold & Buhaug, 2021; Li et al., 2024), can only be addressed with geocoding events in future iterations of the database.

All of the compiled datasets are subject to several biases. The first one is the temporal bias, as systematic reporting and monitoring becomes more reliable over time. This issue has been extensively discussed for EM-DAT and similar datasets as DesInventar (Panwar & Sen, 2019; Jones et al., 2023). More precisely, these datasets show underreporting data for a number of event categories such as earthquakes and hydro-meteorological disasters (Alimonti & Mariani, 2024; Joshi et al., 2024a). Second, the threshold bias, which *de facto* evicts all events that do not meet the criteria thresholds defined by the original studies authors. Third is the hazard bias, meaning that our analysis is naturally limited to the shock types we have included, but misses some others, such as social unrest, migration, political crises and trade conflicts (Wyatt et al., 2023). Fourth is the geographic bias, as Global North countries have more available reporting on disasters than Global South countries (Mahecha et al., 2020). Fifth is the accounting bias, as the impact data for disasters (in casualties or U.S. dollars) is highly challenged as a large proportion of data between 1990 and 2020 is missing (Jones et al., 2022). Sixth and final is the systemic bias, when previous biases interact, compounding their effects.

We tried to limit those biases by having a comprehensive and transparent method, in which we (i) carried out an initial survey of existing datasets to select the best ones according to robustness and coverage criteria (systemic bias); (ii) compared the results from the selected datasets to other more specific datasets (threshold and hazard bias); (iii) standardized each dataset according to a common template (systemic bias); (iv) checked robustness periods of each dataset through literature review and did not use data which was deemed not robust-such as EM-DAT before 1970, as supported to by Jones et al. (2020) and Lee et al. (2024); (v) explored the sensitivity of the co-occurrence analysis to the exclusion of shock categories, and (vi) disregarded impact data. We believe that this protocol, still improvable, is the first step towards a comprehensive assessment of national and international shocks.

Future development of the present work could include the integration of more fine grained data (potentially combining regional and spatially-explicit datasets), the addition of creeping changes, or the identification of emerging typologies of shocks combining the database with case studies. A more in-depth sensitivity analysis based, for example, on MYRIAD-Hazard Event Sets Algorithm (MYRIAD-HESA) of Claasen et al. (2023), and an exploration of how the use of impacts and drivers affects the robustness of the database could also be carried out in the future to better assess the robustness of our findings. In addition, future work could explore weighting shocks by severity (e.g., fatalities, economic losses, or damages incurred), though such efforts would require careful consideration of known biases and inconsistencies in impact reporting, particularly across shock types and regions. Finally, future iterations of the database—with improved temporal and spatial resolution—will enable more precise analyses of temporal relationships between shocks, including trends in shock frequency and potential sequencing patterns across regions and shock types.

5. Conclusion

This study offers a first empirical overview of the temporal and spatial dynamics of national-level shocks across 175 countries from 1970 to 2019, highlighting their evolving co-occurrence patterns as an entry point into the study of polycrisis. Our findings indicate that while shocks became increasingly co-occurring until 2000—particularly within and between climate, conflict, and technological categories—this trend has since plateaued or diverged across regions. Such regionally heterogeneous trajectories challenge the assumption of a globally uniform escalation of crisis entanglement and call for greater attention to the spatial specificity of polycrisis processes. Our analysis also highlights the importance of disaggregating shocks by category and context, revealing that certain combinations recur more frequently and may signal structurally embedded vulnerabilities. These insights speak to broader debates within polycrisis, multi-hazard, and resilience research, and stress the need for frameworks capable of capturing both systemic interdependencies and localized dynamics. Ultimately, we hope this work contributes toward building a common empirical foundation for navigating polycrisis, informing both theoretical developments and practical approaches to adaptive governance.

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Author Contributions

Louis Delannoy: Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. **Alexandre Verzier**: Data Curation, Investigation, Methodology, Visualization. **Bernardo A. Bastien Olvera**: Formal analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **Felipe Benra**: Validation, Visualization, Writing – original draft, Writing – review & editing. **Magnus Nyström**: Writing – review & editing. **Peter Søgaard Jørgensen**: Conceptualization, Supervision, Writing – review & editing.

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Conflicts of Interest declarations

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

Data for the number of national shocks (gross and normalized) per country and per year as well as code for producing figures can be accessed from the following repository: https://github.com/LouisD-KVA/Polycrisis-shocks

Declaration of AI use

We have used AI-assisted technologies for spellchecking, code checking and as inspiration for rewording individual sentences. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

References

Albert, M. J. (2024). Navigating the Polycrisis Mapping the Futures of Capitalism and the Earth. The MIT Press. ISBN: 9780262547758

Alimonti, G., & Mariani, L. (2023). Is the number of global natural disasters increasing? Environmental Hazards (Vol. 23, Issue 2, pp. 186–202). Informa UK Limited. https://doi.org/10.1080/17477891.2023.2239807

Baker, R. E., Mahmud, A. S., Miller, I. F., Rajeev, M., Rasambainarivo, F., Rice, B. L., Takahashi, S., Tatem, A. J., Wagner, C. E., Wang, L., Wesolowski, A., & Metcalf, C. J. E. (2021). Infectious disease in an era of global change. Nature Reviews Microbiology, 20(4), 193–205. https://doi.org/10.1038/s41579-021-00639-z

Beauchamp, E., Hirons, M., Brown, K., & Milner-Gulland, E. (2020). Twenty priorities for future social-ecological research on climate resilience. Environmental Research Letters (Vol. 15, Issue 10, p. 105006). IOP Publishing. https://doi.org/10.1088/1748-9326/abb157

Biggs, D., Biggs, R. O., Dakos, V., Scholes, R.J. & Schoon, M. (2011). Are we entering an era of concatenated global crises? Ecology and Society (Vol. 16, Issue 2). http://www.ecologyandsociety.org/vol16/iss2/art27

Biggs, R. O., Peterson, G. D., & Rocha, J. C. (2015). The Regime Shifts Database: a framework for analyzing regime shifts in social-ecological systems. Ecology and Society. https://doi.org/10.1101/018473

Boin, A., Ekengren, M., & Rhinard, M. (2021). Understanding the creeping crisis. In Springer eBooks. https://doi.org/10.1007/978-3-030-70692-0

Carlson, C. J., Boyce, M. R., Dunne, M., Graeden, E., Lin, J., Abdellatif, Y. O., Palys, M. A., Pavez, M., Phelan, A. L., & Katz, R. (2023). The World Health Organization's Disease Outbreak News: A retrospective database. C. A. Mendez (Ed.), PLOS Global Public Health (Vol. 3, Issue 1, p. e0001083). Public Library of Science (PLoS). https://doi.org/10.1371/journal.pgph.0001083

Carper, J. M., Alizadeh, M. R., Adamowski, J. F., Inam, A., & Malard, J. J. (2021). Quantifying the transient shock response of dynamic agroecosystem variables for improved socio-environmental resilience. Ecology and Society (Vol. 26, Issue 2). Resilience Alliance, Inc. https://doi.org/10.5751/es-12354-260217

Claassen, J. N., Ward, P. J., Daniell, J., Koks, E. E., Tiggeloven, T., & de Ruiter, M. C. (2023). A new method to compile global multi-hazard event sets. Scientific Reports (Vol. 13, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1038/s41598-023-40400-5

Cooper, G. S., Willcock, S., & Dearing, J. A. (2020). Regime shifts occur disproportionately faster in larger ecosystems. Nature Communications (Vol. 11, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1038/s41467-020-15029-x

Cottrell, R. S., Nash, K. L., Halpern, B. S., Remenyi, T. A., Corney, S. P., Fleming, A., Fulton, E. A., Hornborg, S., Johne, A., Watson, R. A., & Blanchard, J. L. (2019). Food production shocks across land and sea. Nature Sustainability (Vol. 2, Issue 2, pp. 130–137). Springer Science and Business Media LLC. https://doi.org/10.1038/s41893-018-0210-1

Cumming, G. S., & Peterson, G. D. (2017). Unifying Research on Social–Ecological Resilience and Collapse. Trends in Ecology & Evolution (Vol. 32, Issue 9, pp. 695–713). Elsevier BV. https://doi.org/10.1016/j.tree.2017.06.014

Delforge, D., Wathelet, V., Below, R., Sofia, C. L., Tonnelier, M., Loenhout, J. van, & Speybroeck, N. (2023). EM-DAT: the Emergency Events Database. Research Square Platform LLC. https://doi.org/10.21203/rs.3.rs-3807553/v1

Diehl, P. F., Goertz, G., & Gallegos, Y. (2019). Peace data: Concept, measurement, patterns, and research agenda. Conflict Management and Peace Science, 38(5), 605–624. https://doi.org/10.1177/0738894219870288

Dornelles, A. Z., Boyd, E., Nunes, R. J., Asquith, M., Boonstra, W. J., Delabre, I., Denney, J. M., Grimm, V., Jentsch, A., Nicholas, K. A., Schröter, M., Seppelt, R., Settele, J., Shackelford, N., Standish, R. J., Yengoh, G. T., & Oliver, T. H. (2020). Towards a bridging concept for undesirable resilience in social-ecological systems. Global Sustainability (Vol. 3). Cambridge University Press (CUP). https://doi.org/10.1017/sus.2020.15

d'Errico, M., Pinay, J., Jumbe, E., & Luu, A. H. (2023). Drivers and stressors of resilience to food insecurity: evidence from 35 countries. Food Security (Vol. 15, Issue 5, pp. 1161–1183). Springer Science and Business Media LLC. https://doi.org/10.1007/s12571-023-01373-5

Fischer, J., Gardner, T. A., Bennett, E. M., Balvanera, P., Biggs, R., Carpenter, S., Daw, T., Folke, C., Hill, R., Hughes, T. P., Luthe, T., Maass, M., Meacham, M., Norström, A. V., Peterson, G., Queiroz, C., Seppelt, R., Spierenburg, M., & Tenhunen, J. (2015). Advancing sustainability through mainstreaming a social–ecological systems perspective. Current Opinion in Environmental Sustainability, 14, 144–149. https://doi.org/10.1016/j.cosust.2015.06.002

Fisher, M. C., Moore, S. K., Jardine, S. L., Watson, J. R., & Samhouri, J. F. (2021). Climate shock effects and mediation in fisheries. Proceedings of the National Academy of Sciences (Vol. 118, Issue 2). PNAS. https://doi.org/10.1073/pnas.2014379117

Folke, C., Polasky, S., Rockström, J., Galaz, V., Westley, F., Lamont, M., Scheffer, M., Österblom, H., Carpenter, S. R., Chapin, F. S., III, Seto, K. C., Weber, E. U., Crona, B. I., Daily, G. C., Dasgupta, P., Gaffney, O., Gordon, L. J., Hoff, H., Levin, S. A., … Walker, B. H. (2021). Our future in the Anthropocene biosphere. Ambio (Vol. 50, Issue 4, pp. 834–869). Springer Science and Business Media LLC. https://doi.org/10.1007/s13280-021-01544-8

Franzke, C. L. E., & Czupryna, M. (2021). Global risks of infectious disease outbreaks and its relation to climate. Environmental Research Letters (Vol. 16, Issue 8, p. 084063). IOP Publishing. https://doi.org/10.1088/1748-9326/ac188c

Free, C. M., Mangin, T., Molinos, J. G., Ojea, E., Burden, M., Costello, C., & Gaines, S. D. (2020). Realistic fisheries management reforms could mitigate the impacts of climate change in most countries. J. Hewitt (Ed.), PLOS ONE (Vol. 15, Issue 3, p. e0224347). Public Library of Science (PLoS). https://doi.org/10.1371/journal.pone.0224347

Gephart, J. A., Deutsch, L., Pace, M. L., Troell, M., & Seekell, D. A. (2017). Shocks to fish production: Identification, trends, and consequences. Global Environmental Change (Vol. 42, pp. 24–32). Elsevier BV. https://doi.org/10.1016/j.gloenvcha.2016.11.003

Goldstein, J. E., Neimark, B., Garvey, B., & Phelps, J. (2023). Unlocking "lock-in" and path dependency: A review across disciplines and socio-environmental contexts. World Development (Vol. 161, p. 106116). Elsevier BV. https://doi.org/10.1016/j.worlddev.2022.106116

Hegre, H., Croicu, M., Eck, K., & Högbladh, S. (2020). Introducing the UCDP Candidate Events Dataset. Research & Politics (Vol. 7, Issue 3, p. 205316802093525). SAGE Publications. https://doi.org/10.1177/2053168020935257

Hodbod, J., & Eakin, H. (2015). Adapting a social-ecological resilience framework for food systems. Journal of Environmental Studies and Sciences (Vol. 5, Issue 3, pp. 474–484). Springer Science and Business Media LLC. https://doi.org/10.1007/s13412-015-0280-6

Hopper, G. P., Rattray, G., Schuermann, T., & Power, B. (2023). Stress Testing in a World of Compound Risks and Polycrises. SSRN Electronic Journal. Elsevier BV. https://doi.org/10.2139/ssrn.4504588

Homer-Dixon, T., Walker, B., Biggs, R., Crépin, A.-S., Folke, C., Lambin, E. F., Peterson, G. D., Rockström, J., Scheffer, M., Steffen, W., & Troell, M. (2015). Synchronous failure: the emerging causal architecture of global crisis. Ecology and Society (Vol. 20, Issue 3). Resilience Alliance, Inc. https://doi.org/10.5751/es-07681-200306

Hoyer, D., Bennett, J. S., Reddish, J., Holder, S., Howard, R., Benam, M., Levine, J., Ludlow, F., Feinman, G., & Turchin, P. (2023). Navigating polycrisis: long-run socio-cultural factors shape response to changing climate. Philosophical Transactions of the Royal Society B: Biological Sciences (Vol. 378, Issue 1889). The Royal Society. https://doi.org/10.1098/rstb.2022.0402

Hoyer, D., Holder, S. L., Bennett, J. S., François, P., Whitehouse, H., Covey, A., Feinman, G., Korotayev, A., Vustiuzhanin, V., Preiser-Kapeller, J., Bard, K., Levine, J., Reddish, J., Orlandi, G., Ainsworth, R., & Turchin, P. (2024). All Crises are Unhappy in their Own Way: The role of societal instability in shaping the past. Center for Open Science. https://doi.org/10.31235/osf.io/rk4gd

Jacobs, M. (2024). After Neoliberalism: Economic Theory and Policy in the Polycrisis. The Political Quarterly. Wiley. https://doi.org/10.1111/1467-923x.13363

Jones, R. L., Guha-Sapir, D., & Tubeuf, S. (2022). Human and economic impacts of natural disasters: can we trust the global data? Scientific Data (Vol. 9, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1038/s41597-022-01667-x

Jones, R. L., Kharb, A., & Tubeuf, S. (2023). The untold story of missing data in disaster research: a systematic review of the empirical literature utilising the Emergency Events Database (EM-DAT). Environmental Research Letters (Vol. 18, Issue 10, p. 103006). IOP Publishing. https://doi.org/10.1088/1748-9326/acfd42

Joshi, N., Roberts, R., Tryggvason, A., & Lund, B. (2024a). Earthquake Disaster Fatality Data: Temporally Stable Power Law Behavior and Effects of Underreporting. Seismological Research Letters. Seismological Society of America (SSA). https://doi.org/10.1785/0220230342

Joshi, N., Roberts, R., & Tryggvason, A. (2024b). Incompleteness of natural disaster data and its implications on the interpretation of trends. Environmental Hazards, 1–17. https://doi.org/10.1080/17477891.2024.2377561

Kaplan-Hallam, M., Bennett, N. J., & Satterfield, T. (2017). Catching sea cucumber fever in coastal communities: Conceptualizing the impacts of shocks versus trends on social-ecological systems. Global Environmental Change (Vol. 45, pp. 89–98). Elsevier BV. https://doi.org/10.1016/j.gloenvcha.2017.05.003

Keys, P. W., Galaz, V., Dyer, M., Matthews, N., Folke, C., Nyström, M., & Cornell, S. E. (2019). Anthropocene risk. Nature Sustainability (Vol. 2, Issue 8, pp. 667–673). Springer Science and Business Media LLC. https://doi.org/10.1038/s41893-019-0327-x

Koasidis, K., Nikas, A., & Doukas, H. (2023). Why integrated assessment models alone are insufficient to navigate us through the polycrisis. One Earth (Vol. 6, Issue 3, pp. 205–209). Elsevier BV. https://doi.org/10.1016/j.oneear.2023.02.009

Kopp, R. E., Shwom, R. L., Wagner, G., & Yuan, J. (2016). Tipping elements and climate–economic shocks: Pathways toward integrated assessment. Earth's Future (Vol. 4, Issue 8, pp. 346–372). American Geophysical Union (AGU). https://doi.org/10.1002/2016ef000362

Koubi, V. (2019). Climate change and conflict. Annual Review of Political Science, 22(1), 343–360. https://doi.org/10.1146/annurev-polisci-050317-070830

Laeven, L., & Valencia, F. (2020). Systemic Banking Crises Database II. IMF Economic Review (Vol. 68, Issue 2, pp. 307–361). Springer Science and Business Media LLC. https://doi.org/10.1057/s41308-020-00107-3

LaFree, G., & Dugan, L. (2007). Introducing the Global Terrorism Database. Terrorism and Political Violence (Vol. 19, Issue 2, pp. 181–204). Informa UK Limited. https://doi.org/10.1080/09546550701246817

Lawrence, M., Homer-Dixon, T., Janzwood, S., Rockstöm, J., Renn, O., & Donges, J. F. (2024a). Global polycrisis: the causal mechanisms of crisis entanglement. Global Sustainability (Vol. 7). Cambridge University Press (CUP). https://doi.org/10.1017/sus.2024.1

Lawrence, M. et al. (2024b). Polycrisis Research and Action Roadmap 2024: Gaps, opportunities, and priorities for polycrisis research and action. Cascade Institute. https://cascadeinstitute.org/technical-paper/polycrisisroadmap/

Li, N., Zahra, S., Madruga de Brito, M., Flynn, C. M., Görnerup, O., Worou, K., Kurfalı, M., Meng, C., Tiery, W., Zscheischler, J., Messori, G., & Nivre, J. (2024). 'Using LLMs to Build a Database of Climate Extreme Impacts'. Proceedings of the 1st Workshop on Natural Language Processing Meets Climate Change. https://aclanthology.org/2024.climatenlp-1.7.pdf

Mahecha, M. D., Guha-Sapir, D., Smits, J., Gans, F., & Kraemer, G. (2020). Data challenges limit our global understanding of humanitarian disasters triggered by climate extremes. Climate Extremes and Their Implications for Impact and Risk Assessment (pp. 243–256). Elsevier. https://doi.org/10.1016/b978-0-12-814895-2.00013-6

Magnan, A. K., Schipper, E. L. F., Burkett, M., Bharwani, S., Burton, I., Eriksen, S., Gemenne, F., Schaar, J., & Ziervogel, G. (2016). Addressing the risk of maladaptation to climate change. WIREs Climate Change (Vol. 7, Issue 5, pp. 646–665). Wiley. https://doi.org/10.1002/wcc.409

Mark, S., Holder, S., Hoyer, D., Schoonover, R., & Aldrich, D. P. (2024a). Understanding Polycrisis: Definitions, Applications, and Responses. SSRN Electronic Journal. Elsevier BV. https://doi.org/10.2139/ssrn.4593383

Mark, S., Rodrigues, M. S., Holder, S., Hoyer, D., Schoonover, R., & Aldrich, D. P. (2024b). Quantitative Analysis of EMDAT Indicates Changes in Disaster Trends over 124 Years Associated with Polycrisis. SSRN. https://doi.org/10.2139/ssrn.4967313

Mester, B., Frieler, K., & Schewe, J. (2023). Human displacements, fatalities, and economic damages linked to remotely observed floods. Scientific Data (Vol. 10, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1038/s41597-023-02376-9

Milkoreit, M., Hodbod, J., Baggio, J., Benessaiah, K., Calderón-Contreras, R., Donges, J. F., Mathias, J.-D., Rocha, J. C., Schoon, M., & Werners, S. E. (2018). Defining tipping points for social-ecological systems scholarship—an interdisciplinary literature review. Environmental Research Letters (Vol. 13, Issue 3, p. 033005). IOP Publishing. https://doi.org/10.1088/1748-9326/aaaa75

Méndez, P. F., Fajardo-Ortiz, D., & Holzer, J. M. (2022). Disrupting the governance of social-ecological rigidity traps: Can pluralism foster change towards sustainability? Advances in Ecological Research (pp. 243–291). Elsevier. https://doi.org/10.1016/bs.aecr.2022.04.011

Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., Walker, B., Birkmann, J., Van Der Leeuw, S., Rockström, J., Hinkel, J., Downing, T., Folke, C., & Nelson, D. (2010). Resilience and vulnerability: complementary or conflicting concepts? Ecology and Society, 15(3). https://www.jstor.org/stable/26268184

Naghavi, M., Vollset, S. E., Ikuta, K. S., Swetschinski, L. R., Gray, A. P., Wool, E. E., Aguilar, G. R., Mestrovic, T., Smith, G., Han, C., Hsu, R. L., Chalek, J., Araki, D. T., Chung, E., Raggi, C., Hayoon, A. G., Weaver, N. D., Lindstedt, P. A., Smith, A. E., . . . Murray, C. J. L. (2024). Global burden of bacterial antimicrobial resistance 1990–2021: a systematic analysis with forecasts to 2050. The Lancet. https://doi.org/10.1016/s0140-6736(24)01867-1

Nguyen, T. C., Castro, V., & Wood, J. (2022). A new comprehensive database of financial crises: Identification, frequency, and duration. Economic Modelling (Vol. 108, p. 105770). Elsevier BV. https://doi.org/10.1016/j.econmod.2022.105770

Nicoli, F., & Zeitlin, J. (2024). Introduction: escaping the politics trap? EU integration pathways beyond the polycrisis. Journal of European Public Policy, 31(10), 3011–3035. https://doi.org/10.1080/13501763.2024.2366395

Nones, M., Hamidifar, H., & Shahabi-Haghighi, S. M. B. (2023). Exploring EM-DAT for depicting spatiotemporal trends of drought and wildfires and their connections with anthropogenic pressure. Natural Hazards (Vol. 120, Issue 1, pp. 957–973). Springer Science and Business Media LLC. https://doi.org/10.1007/s11069-023-06209-1

Panwar, V., & Sen, S. (2019). Disaster Damage Records of EM-DAT and DesInventar: A Systematic Comparison. Economics of Disasters and Climate Change (Vol. 4, Issue 2, pp. 295–317). Springer Science and Business Media LLC. https://doi.org/10.1007/s41885-019-00052-0

Radosavljevic, S., Banitz, T., Grimm, V., Johansson, L.-G., Lindkvist, E., Schlüter, M., & Ylikoski, P. (2023). Dynamical systems modeling for structural understanding of social-ecological systems: A primer. Ecological Complexity (Vol. 56, p. 101052). Elsevier BV. https://doi.org/10.1016/j.ecocom.2023.101052

Renaud, F. G., Birkmann, J., Damm, M., & Gallopín, G. C. (2010). Understanding multiple thresholds of coupled social–ecological systems exposed to natural hazards as external shocks. Natural Hazards (Vol. 55, Issue 3, pp. 749–763). Springer Science and Business Media LLC. https://doi.org/10.1007/s11069-010-9505-x

Revault d'Allones, M. (2016). La Crise sans fin. Essai sur l'experience moderne du temps. Éditions POINTS. ISBN: 978-2757862094

Rist, L., Norström, A., & Queiroz, C. (2024). Biodiversity, peace and conflict: understanding the connections. Current Opinion in Environmental Sustainability (Vol. 68, p. 101431). Elsevier BV. https://doi.org/10.1016/j.cosust.2024.101431

Rosvold, E. L., & Buhaug, H. (2021). GDIS, a global dataset of geocoded disaster locations. Scientific Data (Vol. 8, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1038/s41597-021-00846-6

Shaban, A., Kourtit, K., Nijkamp, P., Das, B. (2024). Socio-ecological shocks, weak community support systems, and tragic responses of farmers – A modeling study on India. Regional Science Policy & Practice (Vol. 100030). Elsevier BV. https://doi.org/10.1016/j.rspp.2024.100030

Søgaard Jørgensen, P., Jansen, R. E. V., Avila Ortega, D. I., Wang-Erlandsson, L., Donges, J. F., Österblom, H., Olsson, P., Nyström, M., Lade, S. J., Hahn, T., Folke, C., Peterson, G. D., & Crépin, A.-S. (2023). Evolution of the polycrisis: Anthropocene traps that challenge global sustainability. Philosophical Transactions of the Royal Society B: Biological Sciences (Vol. 379, Issue 1893). The Royal Society. https://doi.org/10.1098/rstb.2022.0261

Stadler, K. (2017). The country converter coco - a Python package for converting country names between different classification schemes. The Journal of Open Source Software (Vol. 2, Issue 16, p. 332). The Open Journal. https://doi.org/10.21105/joss.00332

Thonicke, K., Bahn, M., Lavorel, S., Bardgett, R. D., Erb, K., Giamberini, M., Reichstein, M., Vollan, B., & Rammig, A. (2020). Advancing the Understanding of Adaptive Capacity of Social-Ecological Systems to Absorb Climate Extremes. Earth's Future (Vol. 8, Issue 2). American Geophysical Union (AGU). https://doi.org/10.1029/2019ef001221

Trogrlić, R. Š., Reiter, K., Ciurean, R. L., Gottardo, S., Torresan, S., Daloz, A. S., Ma, L., Fumero, N. P., Tatman, S., Hochrainer-Stigler, S., De Ruiter, M. C., Schlumberger, J., Harris, R., Garcia-Gonzalez, S., García-Vaquero, M., Arévalo, T. L. F., Hernandez-Martin, R., Mendoza-Jimenez, J., Ferrario, D. M., . . . Ward, P. J. (2024). Challenges in assessing and managing multi-hazard risks: A European stakeholders perspective. Environmental Science & Policy, 157, 103774. https://doi.org/10.1016/j.envsci.2024.103774

Viña, A., & Liu, J. (2022). Effects of global shocks on the evolution of an interconnected world. Ambio (Vol. 52, Issue 1, pp. 95–106). Springer Science and Business Media LLC. https://doi.org/10.1007/s13280-022-01778-0

Wang, J., He, Z., & Weng, W. (2020). A review of the research into the relations between hazards in multi-hazard risk analysis. Natural Hazards, 104(3), 2003–2026. https://doi.org/10.1007/s11069-020-04259-3

Walker, B., Crépin, A.-S., Nyström, M., Anderies, J. M., Andersson, E., Elmqvist, T., Queiroz, C., Barrett, S., Bennett, E., Cardenas, J. C., Carpenter, S. R., Chapin, F. S., III, de Zeeuw, A., Fischer, J., Folke, C., Levin, S., Nyborg, K., Polasky, S., Segerson, K., … Vincent, J. R. (2023). Response diversity as a sustainability strategy. Nature Sustainability (Vol. 6, Issue 6, pp. 621–629). Springer Science and Business Media LLC. https://doi.org/10.1038/s41893-022-01048-7

Ward, P. J., Blauhut, V., Bloemendaal, N., Daniell, J. E., De Ruiter, M. C., Duncan, M. J., Emberson, R., Jenkins, S. F., Kirschbaum, D., Kunz, M., Mohr, S., Muis, S., Riddell, G. A., Schäfer, A., Stanley, T., Veldkamp, T. I. E., & Winsemius, H. C. (2020). Review article: Natural hazard risk assessments at the global scale. Natural Hazards and Earth System Sciences, 20(4), 1069–1096. https://doi.org/10.5194/nhess-20-1069-2020

Ward, P. J., Daniell, J., Duncan, M., Dunne, A., Hananel, C., Hochrainer-Stigler, S., Tijssen, A., Torresan, S., Ciurean, R., Gill, J. C., Sillmann, J., Couasnon, A., Koks, E., Padrón-Fumero, N., Tatman, S., Lund, M. T., Adesiyun, A., Aerts, J. C. J. H., Alabaster, A., . . . De Ruiter, M. C. (2022). Invited perspectives: A research agenda towards disaster risk management pathways in multi-(hazard-)risk assessment. Natural Hazards and Earth System Sciences, 22(4), 1487–1497. https://doi.org/10.5194/nhess-22-1487-2022

Wassénius, E., & Crona, B. I. (2022). Adapting risk assessments for a complex future. One Earth (Vol. 5, Issue 1, pp. 35–43). Elsevier BV. https://doi.org/10.1016/j.oneear.2021.12.004

Wyatt, F., Robbins, J., & Beckett, R. (2023). Investigating bias in impact observation sources and implications for impact-based forecast evaluation. International Journal of Disaster Risk Reduction (Vol. 90, p. 103639). Elsevier BV. https://doi.org/10.1016/j.ijdrr.2023.103639

Zeitlin, J., Nicoli, F., & Laffan, B. (2019). Introduction: the European Union beyond the polycrisis? Integration and politicization in an age of shifting cleavages. Journal of European Public Policy, 26(7), 963–976. https://doi.org/10.1080/13501763.2019.1619803

Supplementary material

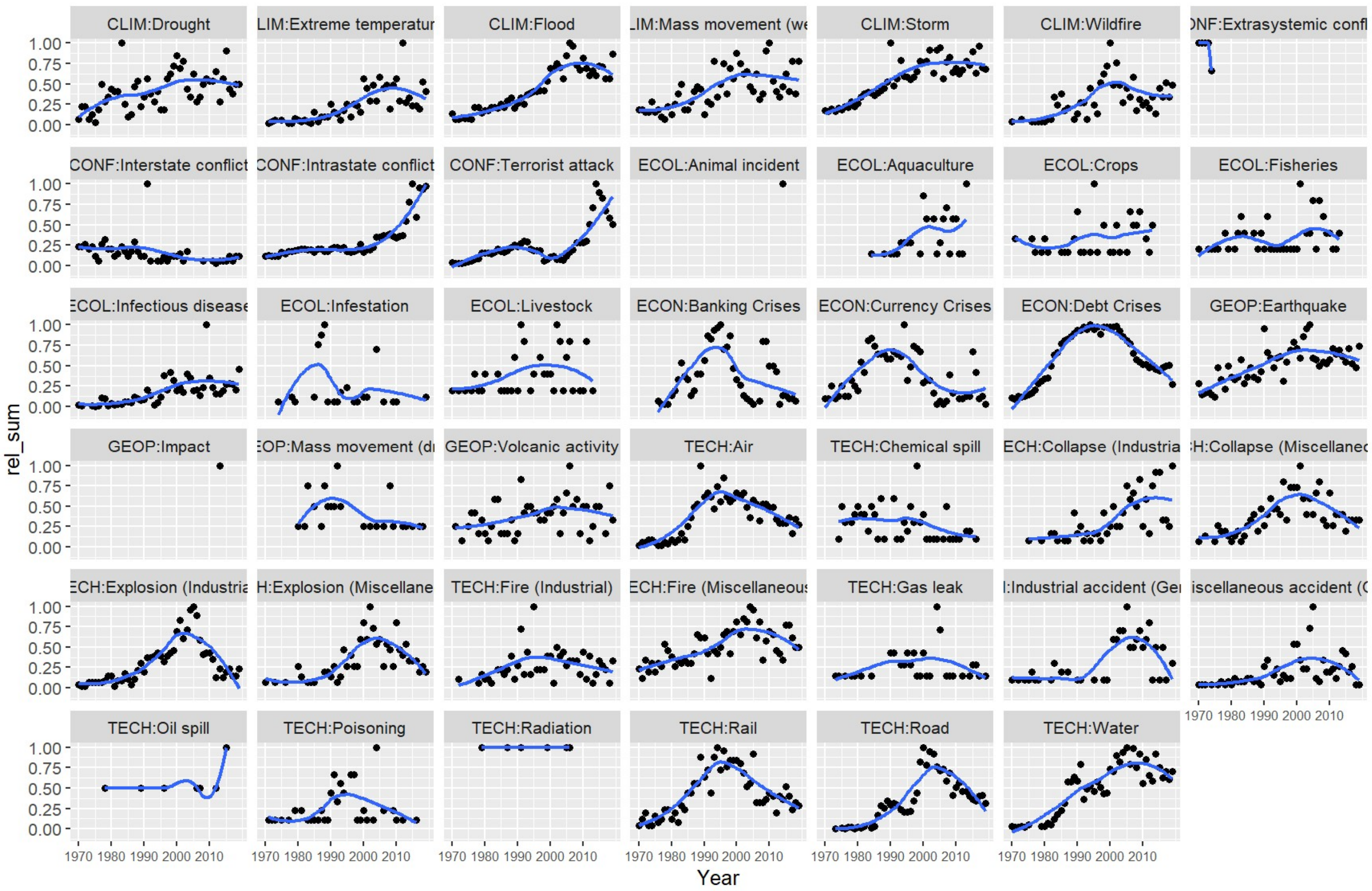

Figure SI-1. Relative sum of shock types over time (1970 - 2019). Each point represents the relative magnitude of a specific shock type within a given year, and blue lines are Loess smoothing.