

GLOBAL RISK & EARTH SYSTEMS RESEARCH REPORT

The Polycrisis Apocalypse

Global catastrophe, survivability risk, and the long-term trajectory of humanity, from unsafe stabilization to deep-time extinction

Author: Hunter Hughes

H Heuristics · Global Risk & Systems Analysis · October 2026

Contents

- 01 Executive Summary.....3
- 02 Defining the Polycrisis Apocalypse.....5
- 03 Crisis Convergence.....7
- 04 The Survivability Risk Envelope.....10
- 05 Expansion of Survivability Risk Regions.....12
- 06 The Geography of Human Exposure.....14
- 07 Degraded Global Stabilization.....21
- 08 Feedback Loops and the Erosion of Resilience.....23
- 09 Centuries: Inherited Damage and Chronic Risk.....26
- 10 Millennia: The Long Tail of Damage.....28
- 11 Deep Time: Tens to Hundreds of Thousands of Years.....30
- 12 Terminal Pathways to Extinction.....32
- 13 Scenario Architecture.....34
- 14 Counterarguments and Uncertainty.....36
- 15 Indicators and Early Warning.....38
- 16 Implications: Breaking the Trajectory.....40
- 17 Conclusion.....42
- A Appendix A: Glossary.....43
- B Appendix B: Sources and Further Reading.....44
- C Appendix C: Methodology and Limitations.....46

Every source is hyperlinked in the text and collected in Appendix B. Figures marked illustrative are conceptual and are not forecasts.

01 Executive Summary

The *Polycrisis Apocalypse* is a framework for thinking about a catastrophe that does not arrive as a single event. Instead of one asteroid, one war or one pandemic, it describes a **long-duration unraveling** in which climate instability, pollution, poverty, ecological degradation, conflict, institutional breakdown and powerful new technologies reinforce one another. The term draws on the language of the [global polycrisis](#) debate, in which several crises interact so that the whole is more dangerous than the sum of its parts.

This report examines the most pessimistic coherent version of that story. A majority of humanity is gradually pushed into **survivability risk regions**, meaning places and conditions where heat, toxic air, unsafe water, hunger, violence, failing health systems and fragile infrastructure threaten life or long-term wellbeing. Civilization does not vanish. It adapts just enough to continue, but it stabilizes at persistently unsafe levels, or it worsens, across centuries, millennia and potentially tens or hundreds of thousands of years. In the terminal scenario, the accumulated damage and a final existential shock end the human story.

CENTRAL THESIS *The defining feature of the Polycrisis Apocalypse is the gap between survival and sustainable survival. Humanity can persist, even prosper in places, while the underlying crisis is never resolved and the margin for survival narrows.*

Key findings

- **The baseline is already severe.** Roughly 2.3 billion people face moderate or severe food insecurity, about 2.2 billion lack safely managed drinking water, and pollution is linked to around nine million deaths a year ([Lancet Commission](#), [FAO SOFI](#)).
- **Six of nine planetary boundaries are transgressed** ([Richardson et al., 2023](#)), and current policies point toward roughly 3°C of warming ([UNEP](#)).
- **The exposed majority is concentrated in Africa and South Asia.** Three to six-plus billion people could face one or more major stressors, and the two regions that contributed least to the damage hold the largest share of those exposed (Section 6).
- **Crises amplify one another.** The research on [synchronous failure](#) and [crisis entanglement](#) shows that shared drivers, feedbacks and common vulnerabilities turn separate problems into a single system risk.
- **Damage outlasts decisions.** Excess CO₂ persists for tens of thousands of years ([Archer, 2009](#)), ice sheets respond over millennia ([Clark et al., 2016](#)), and extinct species do not return on human timescales.
- **The extinction tail is real but uncertain.** Expert estimates place the chance of existential catastrophe this century near 1 in 6 ([Ord, 2020](#)). Most of that risk comes from anthropogenic technologies, which are exactly the risks a degraded, conflict-prone world handles worst.
- **Long instability does not imply certain extinction.** Extinction tens or hundreds of thousands of years out is a hypothetical terminal scenario, not a prediction. The framework's value is showing how a civilization can remain vulnerable long after the initial catastrophe has passed.

How to read this report

Each of the seventeen sections opens on a new page and can be read alone. Sections 2 to 8 build the mechanism: definition, convergence, the risk envelope, regional expansion, the geography of exposure, stabilization and feedback. Sections 9 to 12 follow the trajectory through centuries, millennia and deep time to the terminal outcome. Sections 13 to 17 turn to scenarios, counterarguments, indicators, implications and conclusions. Illustrative figures are labelled as such; figures drawn from published data cite their sources in the caption and in Appendix B.

The five-stage trajectory and indicative timescales

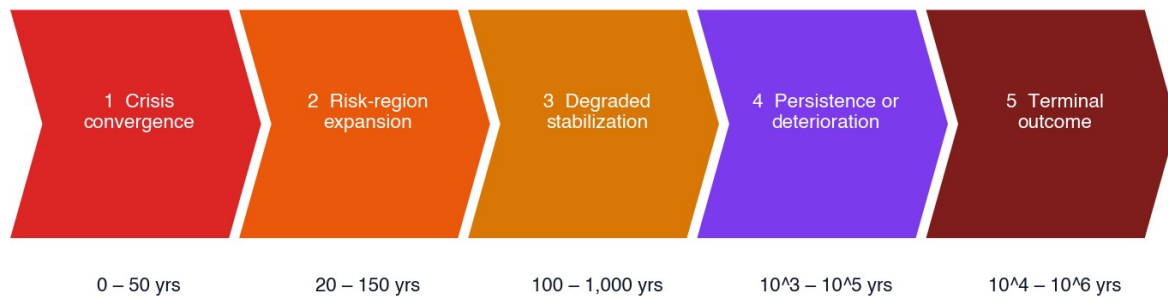


Figure 1. *The five-stage trajectory of the Polycrisis Apocalypse, with indicative timescales. Timescales are conceptual ranges, not forecasts.*

02 Defining the Polycrisis Apocalypse

An apocalypse is usually imagined as an ending: a flash, a wave, a plague that clears the board in months. The Polycrisis Apocalypse is the opposite. It is a **slow-motion catastrophe** that makes the conditions for human life progressively worse and the options for correcting course progressively fewer. The word *apocalypse* is used here in its older sense of an unveiling: the reveal of how interconnected systems fail together.

The term “polycrisis”

The word polycrisis was used by systems thinkers such as Edgar Morin in the 1990s and revived by historian Adam Tooze and the [Cascade Institute](#) to describe a situation in which multiple crises become causally entangled. Researchers define a global polycrisis as a cluster of related global crises that interact in ways that degrade humanity’s prospects far more than any single crisis would ([Lawrence et al.](#)).

The *apocalypse* in this report is what happens when such entanglement is not resolved but **locked in**, and the lock-in is carried across generations. Three ideas define it.

Concept	Meaning in this framework
Crisis convergence	Climate, pollution, poverty, biodiversity loss, conflict and economic disruption interact rather than operate independently.
Survivability risk regions	Places and populations where heat, toxic air, unsafe water, hunger, violence and fragile infrastructure threaten survival or long-term wellbeing.
Unsafe stabilization	Civilization persists and even grows, but around chronic hazard rather than around a sustainable equilibrium.
Deep-time vulnerability	Damage and fragility persist for centuries to geological timescales, leaving humanity exposed to a terminal shock.

The central mechanism: surviving without becoming safe

Humanity does not need to collapse completely for a global catastrophe to become entrenched. Societies can preserve economic output, maintain governments, develop new technologies and support billions of people while substantial populations continue to live in unsafe conditions. In this framework, the persistence of civilization does not indicate that the underlying crisis has been resolved.

The resulting trajectory has three characteristics:

- **Chronic degradation:** humanity survives, but widespread exposure to hazardous conditions persists.
- **Risk accumulation:** new threats compound existing vulnerabilities faster than institutions and technologies can mitigate them.

- **Progressive loss of resilience:** environmental, social or technological change reduces the capacity to withstand future shocks.
- These produce a feedback loop that Section 8 develops fully: crises damage resilience, weakened resilience increases vulnerability to the next crisis, and repeated emergencies divert resources from the investments needed for long-term recovery.

What the framework is and is not

The framework is	The framework is not
A structured way to examine compounding, long-duration risk	A prediction that extinction is inevitable
A pessimistic but internally coherent scenario family	A claim that every region will collapse equally
Focused on exposure, resilience and persistence	Focused on a single hazard or a single date
Explicit about uncertainty at deep timescales	A substitute for quantitative forecasting

NOTE ON TONE *The report is deliberately pessimistic, because the purpose of a pessimistic scenario is to identify the failure modes that optimistic planning ignores. Pessimism here is a method for stress-testing, not a forecast of destiny.*

Intellectual lineage

The framework sits at the junction of several research traditions: [planetary boundaries](#) and Earth-system science; the study of [societal collapse](#) and declining returns to complexity (Tainter); the [existential-risk](#) literature (Bostrom, Ord); and [climate-endgame](#) research on catastrophic tail scenarios (Kemp et al.). The contribution of this report is to join these into a single, time-extended narrative.

03 Crisis Convergence

The first stage of the trajectory is the interaction of crises that are usually analysed in separate silos. Climate scientists study warming, public-health researchers study pollution, economists study poverty, and security analysts study conflict. In reality they act on the same people, in the same places, at the same time.

A coupled network, not a list

Figure 2 sketches the polycrisis as a directed network. Each arrow is a causal pathway: for instance, warming raises food prices, which raise poverty, which feeds conflict, which breaks institutions, which weakens climate adaptation. The diagram is conceptual, but it reflects pathways documented in the literature on [synchronous failure](#), which identifies shared drivers, tightly coupled systems and global connectivity as the architecture of cascading crisis.

The polycrisis as a coupled network



Figure 2. The polycrisis as a coupled network. Arrows denote causal influence; the centre represents the emergent, system-level risk.

Four mechanisms of entanglement

The Cascade Institute's analysis of crisis entanglement identifies several causal mechanisms. Adapted for this report, four stand out:

- **Common drivers.** A single underlying cause, such as fossil-fuel dependence, produces multiple crises at once.
- **Cascades.** A failure in one system propagates to the next: crop failure to price spike to unrest to state failure.
- **Compounding hazards.** Simultaneous shocks, such as heat during a pandemic or flooding during a debt crisis, strain the same response capacity.
- **Capacity erosion.** Each crisis consumes the money, attention, trust and institutional bandwidth needed to handle the next.

The cross-crisis influence matrix

Figure 3 scores how strongly each system drives each other system. Reading across a row shows which crises are the most potent *amplifiers*. Reading down a column shows which systems are the most *exposed*. In this illustrative scoring, conflict, institutional fragility and climate are the strongest drivers, while poverty, economy and ecology are the most heavily acted upon.

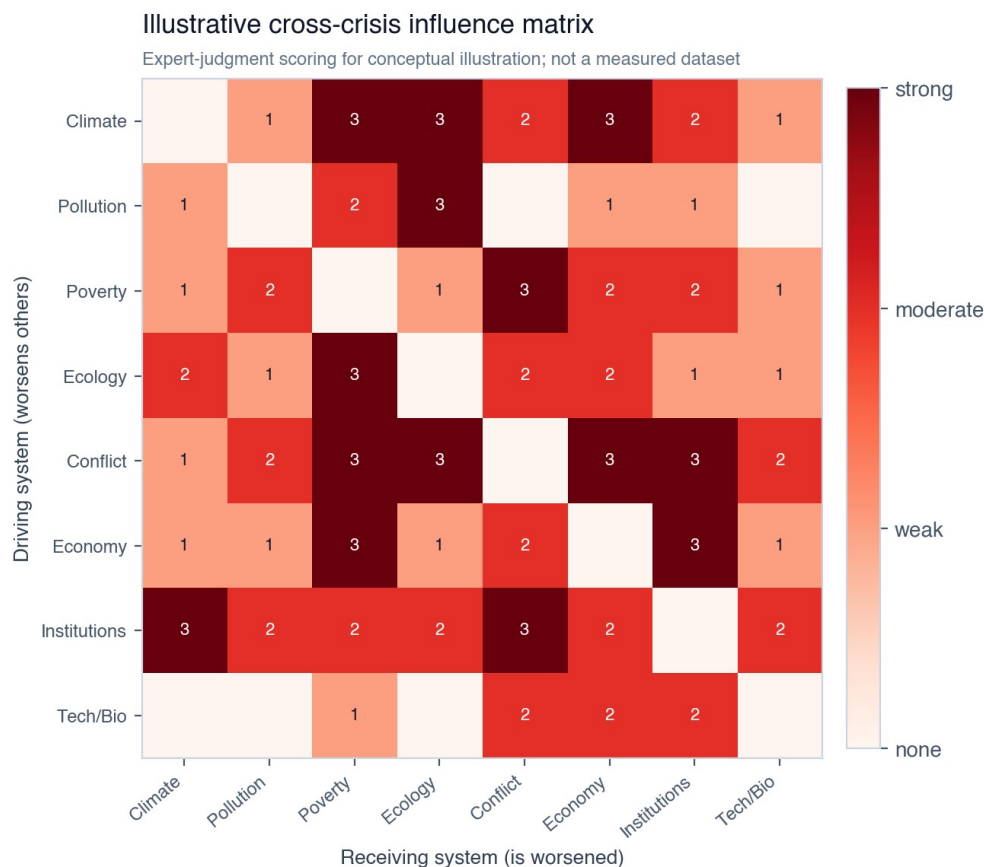
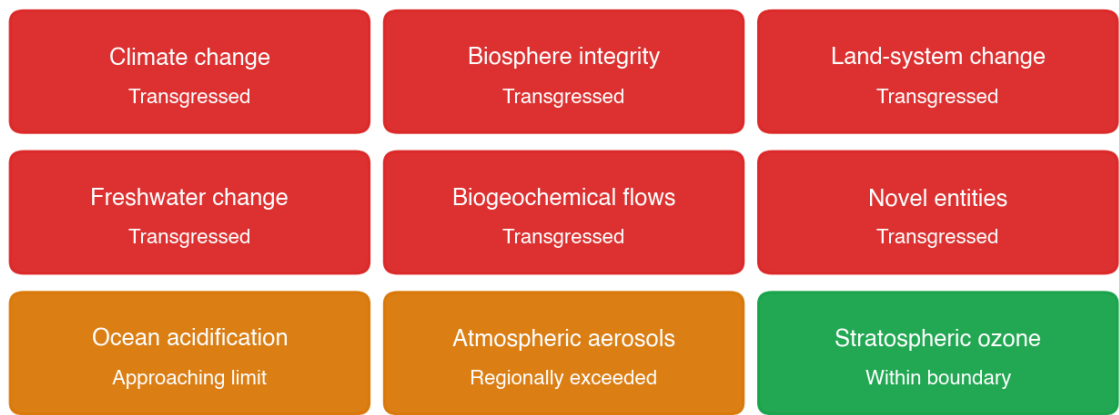


Figure 3. Illustrative cross-crisis influence matrix (expert-judgment scoring for conceptual use only).

Planetary boundaries as the physical substrate

Convergence is physical as well as social. The [planetary boundaries](#) framework tracks nine Earth-system processes. A 2023 update found that **six of nine have been transgressed** ([Richardson et al.](#)). A companion study on [safe and just boundaries](#) adds a fairness dimension: large shares of humanity already live outside conditions that are both ecologically safe and socially just.

Planetary boundary status — six of nine transgressed



Source: Richardson et al. (2023), Science Advances; summary classification by H Heuristics

Figure 4. Status of the nine planetary boundaries, following Richardson et al. (2023).

KEY INSIGHT *Convergence matters because it removes the buffers. A society can absorb a drought, or a war, or a market crash. It struggles to absorb all three while its institutions are distracted, its budgets are depleted and its trust is low.*

04 The Survivability Risk Envelope

The **survivability risk envelope** is the conceptual space in which human populations face environmental, biological, economic or geopolitical conditions that compromise their capacity to survive and maintain stable societies. It is not a single temperature threshold or a formally established scientific boundary. It is a framework for examining how several dimensions of risk overlap and how exposure changes over time.

Seven dimensions of risk

Risk dimension	Potential long-term contribution
Climate instability	Extreme heat, agricultural disruption, coastal hazards and pressure on habitable regions
Pollution	Chronic disease, premature mortality, ecosystem damage and reduced environmental quality
Poverty and inequality	Limited access to food, clean energy, safe housing, sanitation and healthcare
Conflict and advanced weapons	Mass casualties, displacement, infrastructure destruction and potentially existential hazards
Ecological degradation	Reduced ecosystem resilience, biodiversity loss and disruption of essential natural systems
Institutional fragility	Diminished capacity to coordinate adaptation, distribute resources and recover from disasters
Technological and biological threats	Potentially catastrophic risks from nuclear escalation, engineered pathogens or other powerful technologies

The key variable is not simply the severity of any one crisis. It is the degree to which multiple hazards coincide with populations that lack the resources, infrastructure and institutional capacity to withstand them.

Exposure = hazard × vulnerability × inability to adapt

The [IPCC](#) frames risk as the product of hazard, exposure and vulnerability. The envelope concept extends this by adding **time** and **adaptive capacity**. A heatwave is survivable in a city with air conditioning, reliable power and a functioning health system. The same heatwave is lethal in a settlement without them. The envelope therefore expands whenever hazards rise *or* adaptive capacity falls.

Where the envelope already is

The envelope is not a future abstraction. Many of its components are measurable today. Figure 5 lists approximate counts of people exposed to different forms of survivability risk. These categories overlap heavily, and they cannot be summed, but together they show that hundreds of millions to several billion people already live inside at least part of the envelope.

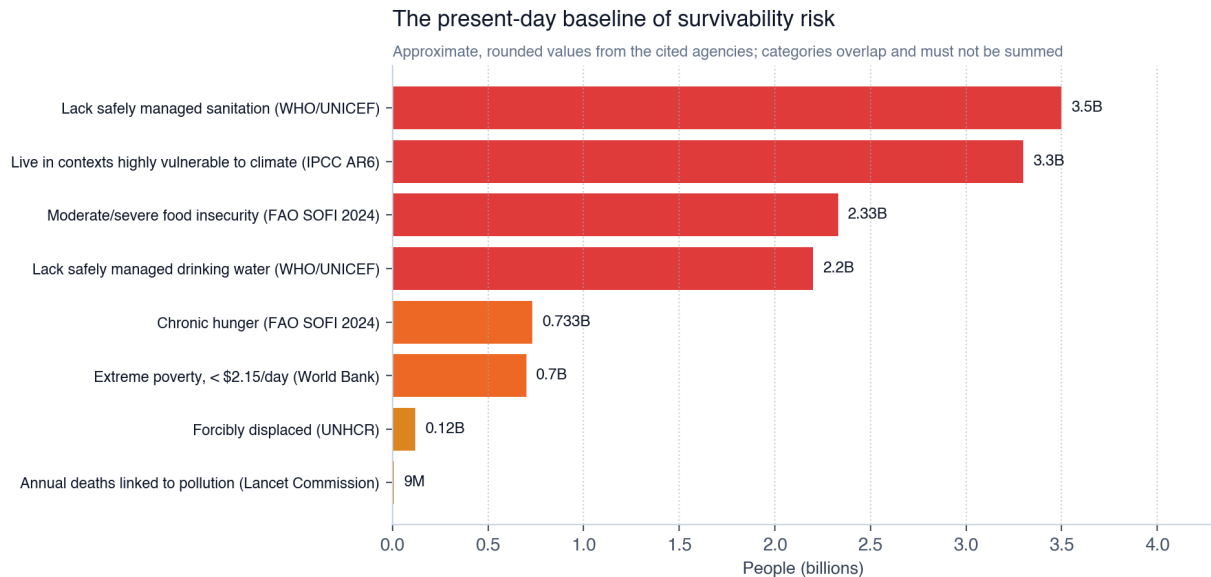


Figure 5. *Present-day baseline indicators. Sources: WHO/UNICEF JMP, FAO SOFI 2024, World Bank, IPCC AR6 WGII, UNHCR, Lancet Commission on Pollution and Health.*

Selected evidence by dimension

- **Climate.** [Xu et al. \(2020\)](#) project that under high emissions and without migration, one to three billion people (about one third of the population) could face mean annual temperatures above 29°C by 2070, conditions found today on only 0.8% of land. [Raymond et al. \(2020\)](#) document humid-heat extremes approaching the limit of human tolerance in parts of South Asia and the Gulf.
- **Pollution.** The [WHO](#) estimates that around 99% of people breathe air that exceeds guideline limits, and the [Lancet Commission](#) attributes about nine million deaths a year, roughly one in six, to pollution.
- **Poverty.** The [World Bank](#) reports around 700 million people in extreme poverty, and close to half of humanity living on less than \$6.85 a day.
- **Conflict.** [UNHCR](#) counts more than 120 million forcibly displaced people, a record. The [Doomsday Clock](#) has been set at its closest ever to midnight, and [SIPRI](#) reports about 12,000 nuclear warheads worldwide.
- **Ecology.** The [IPBES](#) global assessment found around one million species threatened with extinction, a pattern [Ceballos et al.](#) call biological annihilation.
- **Biology.** [The Lancet](#) projects 39 million direct deaths from antimicrobial resistance between 2025 and 2050.

KEY INSIGHT *The envelope is best understood as an overlay map. Wherever heat, hunger, pollution, violence and weak institutions overlap on the same population, survivability risk is highest. The Polycrisis Apocalypse is the scenario in which that overlap map keeps growing.*

05 Expansion of Survivability Risk Regions

The second stage of the trajectory is geographic and demographic: **increasing numbers of people inhabit environments where exposure to heat, toxic air, unsafe water, food insecurity, violence, inadequate healthcare and fragile infrastructure threatens survival or long-term wellbeing.** This section describes the major expansion pathways and why they tend to reinforce each other.

Pathway 1: heat and the shrinking human climate niche

Human populations have historically clustered in a narrow band of mean annual temperature, centred around 13°C, with a smaller peak near 27°C. [Xu et al.](#) showed that, with continued high emissions and population growth, the geographic position of this niche would shift more in 50 years than in the previous six millennia, leaving an estimated one to three billion people in mean annual temperatures above 29°C by 2070. The people most exposed are concentrated in the places with the least capacity to adapt: the Sahel, South Asia, and parts of the Middle East and Southeast Asia.

The [Lancet Countdown](#) reports that heat-related mortality among older adults rose by 167% relative to the 1990s (2013–22 average). [Mora et al.](#) estimate that by 2100, up to three-quarters of the world's population could be exposed to deadly heat conditions for at least 20 days a year under high emissions.

Pathway 2: water, food and agricultural disruption

Water and food systems are the shock absorbers of civilization, and they are tightly coupled to climate. The [FAO](#) estimates that 733 million people faced hunger in 2023, and about 2.3 billion experienced moderate or severe food insecurity. Concentrated breadbasket dependence, groundwater depletion, soil degradation and heat stress on crops all push in the same direction. Where food and water fail, displacement and conflict follow.

Pathway 3: toxic environments

Pollution is unusual among the polycrisis drivers because it can degrade survivability *even where the economy is growing*. Air, water and soil contamination, chemical exposure and microplastics impose a chronic health burden that is largely invisible to GDP. The planetary boundary for [novel entities](#) is judged to be exceeded, and the bulk of those substances (PFAS, plastics, persistent chemicals) will remain in the environment for centuries.

Pathway 4: conflict, displacement and state fragility

Violence and displacement are both consequences and drivers of the other pathways. Fragile and conflict-affected states hold a rising share of the world's extreme poor and are the least able to adapt to climate shocks. Forced displacement removes people from social safety nets and concentrates them in places, such as camps and informal settlements, with high health risk.

Pathway 5: health system strain

Antimicrobial resistance, new zoonotic pathogens, heat illness and chronic pollution disease all load the same underfunded health systems. As noted in the [Lancet AMR analysis](#), the burden falls disproportionately on low-income regions.

From risk regions to a risk majority

A “survivability risk region” is not an all-or-nothing label. Figure 6 shows an illustrative scenario in which the share of humanity in the *high* and *critical* risk tiers grows while the secure share erodes. The trend crosses the symbolic point at which a majority of people live with materially elevated survival risk. Any specific numbers are illustrative; the shape is the point.

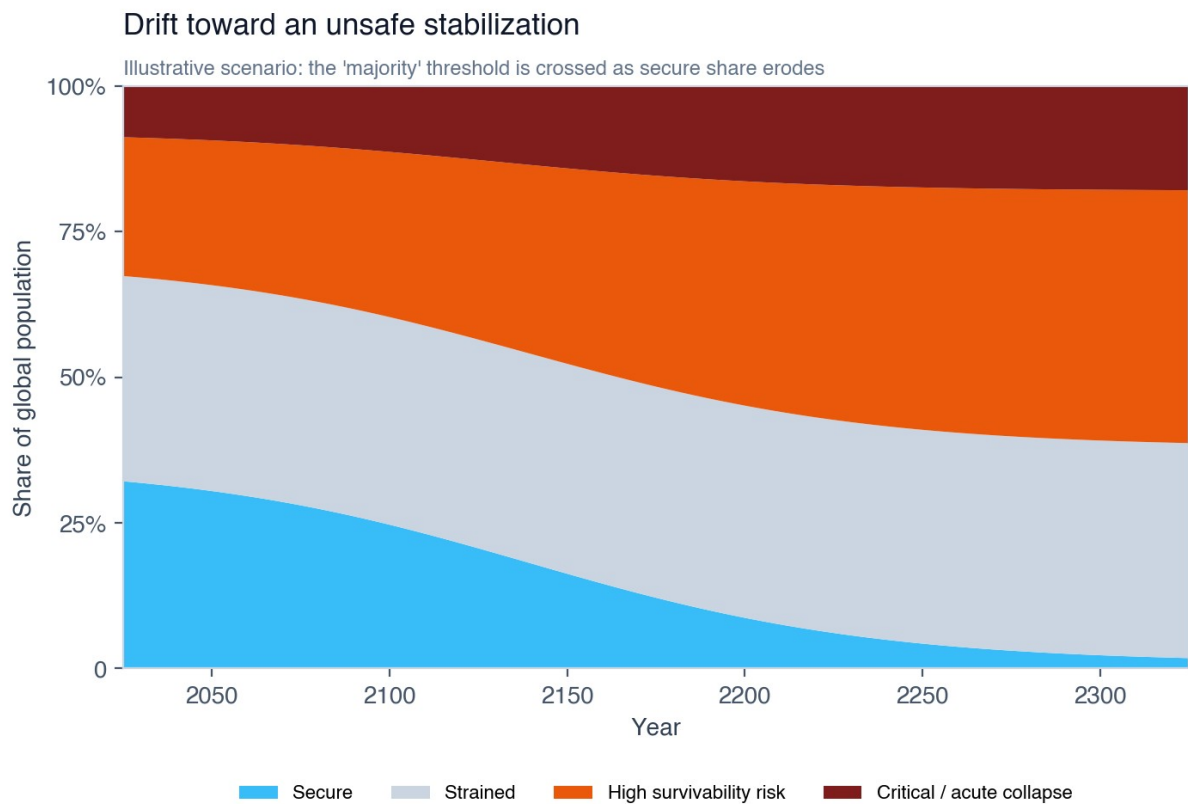


Figure 6. Illustrative drift of the global population into higher-risk tiers under an unsafe-stabilization scenario.

Tier	Characteristics	Typical exposure
Secure	Stable institutions, reliable infrastructure, strong adaptive capacity	Occasional shocks buffered by insurance, health systems and public works
Strained	Functional but stretched services; rising cost of living with hazard	Recurring losses; widening inequality of protection
High risk	Multiple hazards coincide with low adaptive capacity	Chronic disease, food and water stress, recurring displacement
Critical	Acute collapse of services, security or habitability	Mass mortality events, forced migration, state failure

06 The Geography of Human Exposure

The Polycrisis Apocalypse is not evenly distributed. Its hazards are global, but the people who will live inside them are overwhelmingly concentrated in a few regions. **Africa and South Asia are the center of gravity:** they combine the fastest-growing populations, the highest present-day exposure to heat, hunger, unsafe water and fragility, and the lowest capacity to adapt. As a result, a majority of the exposed population is likely to condense into the Global South, and the scenario of Sections 5 to 8 is in geographic terms largely a story about these two regions.

CENTRAL CLAIM *The strongest published anchor is the IPCC finding that 3.3 to 3.6 billion people already live in contexts highly vulnerable to climate change. Scaled to UN population projections, that implies roughly 4 to 6 billion people by mid-century and 4 to 6+ billion by 2100. No study counts everyone exposed to at least one stressor, so the forward range is this report's own arithmetic, shown transparently below.*

Demography is destiny: where the people will be

According to the [UN World Population Prospects 2024](#) (medium variant), Africa has about 1.5 billion people today and is projected to reach about 2.5 billion by 2050 and 3.8 billion by 2100, with sub-Saharan Africa accounting for nearly all of that growth. The eight countries of South Asia hold about 2.0 billion today, rising to roughly 2.4 billion by 2050 and about 2.5 billion around 2075 before easing to 2.4 billion in 2100. Together the two regions hold about 43% of humanity today. That share rises to about 50% in 2050, 57% in 2075 and **61% in 2100**, even as world population peaks near 10.3 billion in the 2080s.

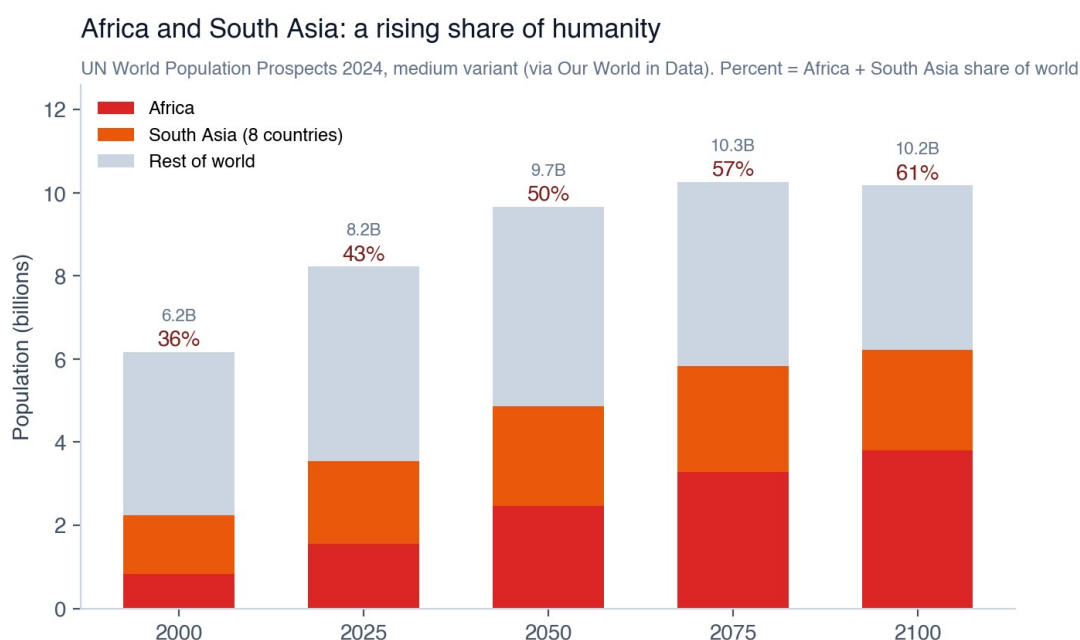


Figure 7. Africa and South Asia as a share of world population, 2000–2100. Data: UN World Population Prospects 2024, medium variant, via Our World in Data.

The significance for the framework is that **population growth is occurring where hazard exposure is highest**. Rising numbers in the Sahel, the Horn of Africa, the Ganges–Brahmaputra delta and the Indus basin mean that every incremental degree of warming and every failed harvest lands on a larger and younger population. Africa’s median age is under 20, which is both a demographic opportunity and, in an unsafe stabilization, a large cohort with limited prospects.

How many billions? What the evidence supports

No published study counts “people exposed to at least one survivability stressor.” What does exist is a set of authoritative counts for individual stressors. They overlap heavily and must never be summed, but the largest of them are all in the multi-billion range.

Stressor	People affected	Source
Highly vulnerable to climate change (multi-factor)	3.3–3.6 billion (high confidence)	IPCC AR6 WGII
Cannot afford a healthy diet	2.6 billion	FAO SOFI 2025
Moderate or severe food insecurity	2.3 billion	FAO SOFI 2025
Lack safely managed drinking water	2.2 billion	WHO/UNICEF JMP
Lack safely managed sanitation	3.5 billion	WHO/UNICEF JMP
Severe water scarcity at least one month a year	About 4 billion	Mekonnen & Hoekstra 2016
Lack clean cooking (household air pollution)	About 2.1 billion	Tracking SDG 7
Exposed to a 1-in-100-year flood	1.81 billion	Rentschler et al. 2022
Acute multidimensional poverty	1.1 billion	UNDP/OPHI Global MPI 2025
Chronic hunger	673 million	FAO SOFI 2025

The IPCC figure is the best single anchor because it is a multi-factor assessment of vulnerability (development, governance, inequality, ecosystem degradation) rather than a single indicator. Several single-stressor counts, such as water scarcity and sanitation, are larger still, but they measure different things.

From today’s count to a forward range

To project the figure forward, this report applies simple, transparent arithmetic to the IPCC count and UN population data. In 2022 world population was about 8.0 billion, so 3.3–3.6 billion corresponds to a vulnerable share of **about 41–45%**. If that share merely stays constant, the vulnerable population grows with world population to **4.0–4.3 billion in 2050** (population 9.7 billion) and **4.2–4.6 billion in 2100** (population 10.2 billion). If worsening heat, fragility and poverty push the share up to 60%, the figures become **5.8 billion in 2050 and 6.1 billion in 2100**.

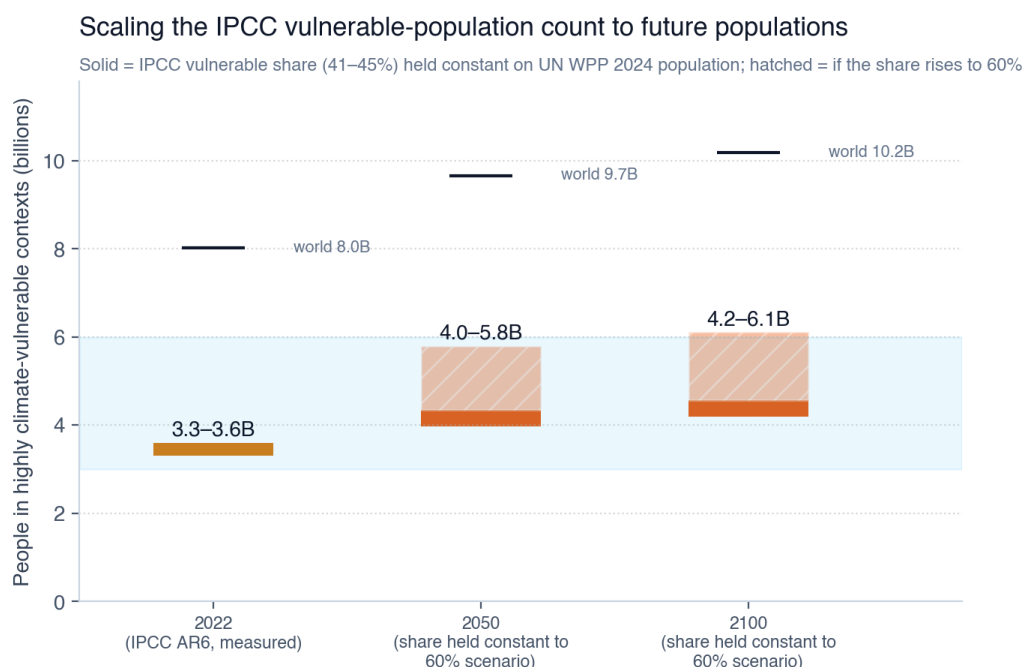


Figure 8. IPCC vulnerable-population count (2022) scaled to UN WPP 2024 populations. Solid bars hold the 41–45% share constant; hatched extensions assume the share rises to 60%. A scenario calculation, not a forecast.

Year	World population	Share held at 41–45%	If share rises to 60%
2022	8.0 billion	3.3–3.6 billion (IPCC)	n/a
2050	9.7 billion	4.0–4.3 billion	5.8 billion
2100	10.2 billion	4.2–4.6 billion	6.1 billion

HOW TO READ THE RANGE The 3–6+ billion band is supported at its lower end by a measured IPCC count and at its upper end by an explicit scenario assumption (a 60% vulnerable share). Other studies point the same direction: [Lenton et al. \(2023\)](#) estimate that current-policy warming of about 2.7°C would leave around 2 billion people outside the human climate niche by 2100, with each additional 0.1°C adding about 140 million.

Evidence that exposure concentrates in Africa and South Asia

The IPCC identifies the highest concentrations of vulnerability in Africa, South Asia, Central and South America, least developed countries and small island states. Four independent datasets show how heavily the exposed are concentrated in the first two.

Indicator	Finding	Source
Share of world population	43% (2025), rising to 61% (2100)	UN WPP 2024
Acute multidimensional poverty	83.2% of the 1.1 billion poor live in sub-Saharan Africa and South Asia	UNDP/OPHI Global MPI 2025

Indicator	Finding	Source
Poor and also climate-exposed	887 million poor people face at least one climate hazard; 651 million face two or more; 309 million face three or four	UNDP/OPHI Global MPI 2025
Extreme poverty	About two-thirds of the world's extreme poor live in sub-Saharan Africa	World Bank , OECD
Chronic hunger	Africa 307 million (more than 1 in 5); Asia 323 million; together about 94% of the 673 million global total	FAO SOFI 2025
Flood exposure	1.24 billion of the 1.81 billion exposed live in South and East Asia; India alone about 390 million	Rentschler et al. 2022

These figures show concentration, but they do not give an exact share of “all people exposed to at least one stressor.” The reasonable reading is that Africa and South Asia hold a **majority** of the most severely exposed, with the remainder in Southeast Asia, the Middle East and North Africa, Latin America and island states.

A regional map of stressors

Figure 9 compares seven world regions across eight stressors. The pattern is stark: sub-Saharan Africa and South Asia score high or very high on almost every dimension, while Europe and North America score low on nearly all of them. The point of the heat map is *overlap*. A region can be stressed on one or two dimensions and still manage, but regions that score high on six or more face the compounding dynamic that defines the Polycrisis Apocalypse.

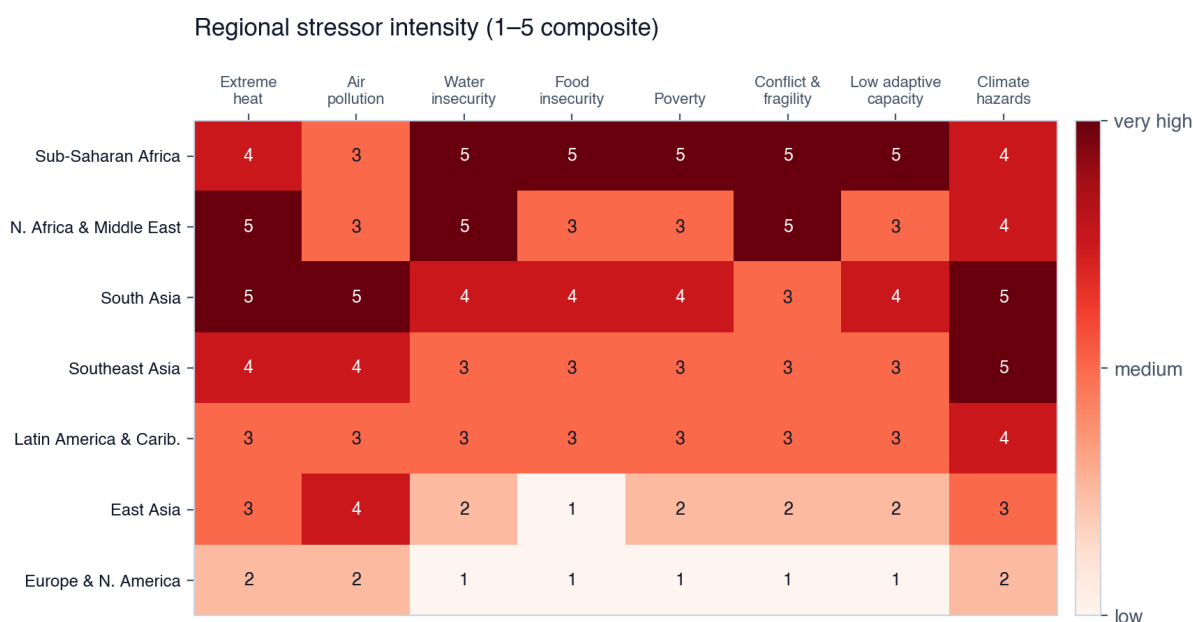


Figure 9. Qualitative composite of stressor intensity by region (1 = low, 5 = very high). H Heuristics synthesis of published indicators; illustrative.

Africa: the demographic frontier under stress

- **Poverty and food.** Sub-Saharan Africa holds about two-thirds of the world's extreme poor ([World Bank](#)), and FAO reports that more than 307 million Africans, over one in five, faced hunger.
- **Heat and rainfall volatility.** The Sahel and the Horn of Africa face rising heat and increasingly erratic rainfall. The Horn has already experienced consecutive failed rainy seasons.
- **Rapid urbanization.** Cities such as Lagos, Kinshasa and Dar es Salaam are growing fast without matching infrastructure, which concentrates people in informal settlements exposed to flooding, heat and disease.
- **Fragility.** Several of the world's most fragile and conflict-affected states are in the Sahel, the Horn and Central Africa, which limits the ability to respond to shocks.
- **Water and sanitation.** Sub-Saharan Africa has the largest absolute and proportional deficits in safely managed drinking water ([WHO/UNICEF JMP](#)).

South Asia: density, heat and toxic air

- **Humid heat.** [Raymond et al. \(2020\)](#) identify the Indus and Ganges valleys among the few places where humid heat is approaching the limit of human tolerance. Densely populated and with many outdoor workers, the region has an exceptionally large number of exposed people.
- **Air pollution.** The [Air Quality Life Index](#) finds that Bangladesh, India, Nepal and Pakistan are the countries where particulate pollution takes the largest toll on life expectancy.
- **Water systems.** The [ICIMOD Hindu Kush Himalaya assessment](#) estimates that roughly 1.65 billion people live in the river basins downstream of the glaciers, which are projected to retreat

substantially. Glacial melt, monsoon variability and groundwater depletion compound one another.

- **Coasts and deltas.** Bangladesh, eastern India and Pakistan's Indus delta combine very high population density with sea-level rise, cyclones and salinization.
- **Nuclear-armed rivalry.** South Asia also contains a nuclear-armed dyad that shares river systems, which links the water and security dimensions of the polycrisis.

Beyond the two core regions

The label “Global South” is broader than Africa and South Asia. Large exposed populations also live in the Middle East and North Africa (extreme heat, water scarcity, conflict), Southeast Asia (deltas, typhoons, sea-level rise), Central America's Dry Corridor (drought-driven migration), and small island states (existential sea-level threats). The [IPCC](#) identifies hotspots of high vulnerability across West, Central and East Africa, South Asia, Central and South America, small island developing states and the Arctic.

The Global North is not immune. Heat waves, wildfire, floods and pollution affect high-income countries, and supply chains, finance and security link them to the Global South. But the Global North has far greater adaptive capacity, which is why its exposure is *strained* rather than *critical* in the tier model of Section 5.

The asymmetry of responsibility and exposure

A defining feature of the geography is that exposure and responsibility run in opposite directions. Africa has contributed about 2.9% of cumulative CO₂ emissions to 2024 and South Asia about 4.1%, according to [Our World in Data](#). Together that is 7%, against a projected 61% of world population in 2100. Europe and North America account for about 57% of cumulative emissions but only about 10% of projected 2100 population.

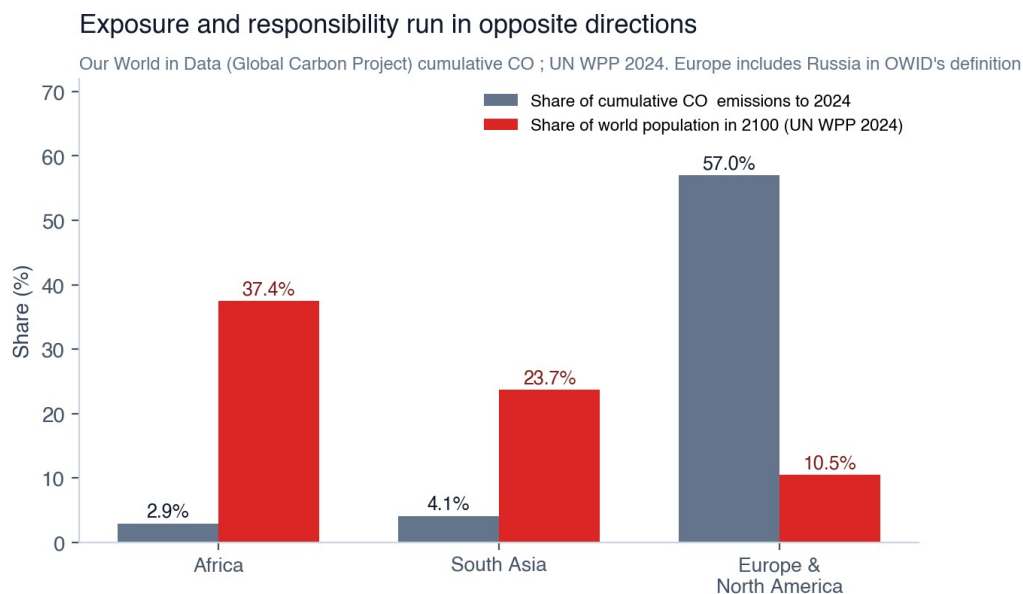


Figure 10. Shares of cumulative emissions versus projected 2100 population. Approximate, rounded values.

The adaptation finance gap compounds the injustice. The [UNEP Adaptation Gap Report 2023](#) estimates that developing countries need \$215–387 billion a year for adaptation, roughly 10 to 18 times current international public adaptation finance, leaving a gap of \$194–366 billion a year. Regions with the least responsibility are therefore also those with the least funded protection.

Displacement and the geography of movement

Exposure does not stay put. The World Bank's [Groundswell report](#) projects up to 216 million internal climate migrants by 2050 across six regions in its pessimistic scenario, and notes that early action could cut this by up to 80%. Sub-Saharan Africa (about 86 million) and South Asia (about 40 million) account for roughly 126 million of that, close to 60%. Most movement is projected to be *within* countries, from drought-hit farmland and flooding coasts to cities that are already stretched, which shifts risk rather than removing it.

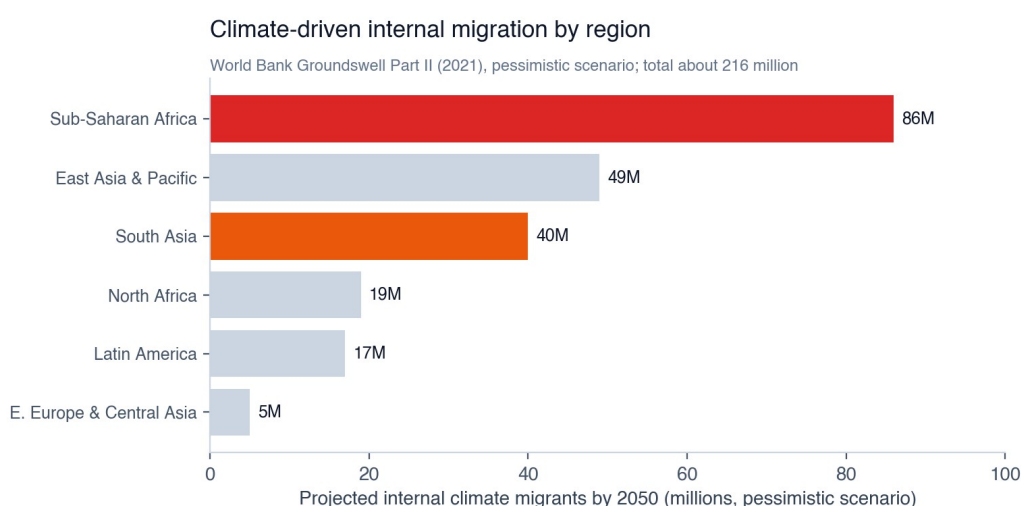


Figure 11. *Projected internal climate migrants by 2050, by region (World Bank Groundswell, pessimistic scenario).*

Geographic lock-in and spillovers

Three consequences follow from this geography, and each bears on the long-run trajectory:

- **Lock-in of risk.** If the exposed majority is concentrated in regions with weak institutions and limited resources, the unsafe stabilization of Section 8 is most likely to emerge there first and to persist longest.
- **Spillovers.** Migration pressure, supply-chain disruption, pandemic risk and instability in the exposed regions feed back into the security and economy of the rest of the world. A crisis that is regionally concentrated is not regionally contained.
- **Governance gravity.** The exposed regions have the largest stake in global outcomes but the least influence over them, which makes coordinated mitigation, finance and tail-risk governance harder.

KEY INSIGHT *The Polycrisis Apocalypse can be read as a Global South crisis with Global North spillovers. The billions inside the survivability risk envelope live mostly in Africa and South Asia, contributed least to the damage, and have the least capacity to escape it.*

07 Degraded Global Stabilization

The third stage is the pivotal one. **Humanity adapts sufficiently to avoid immediate extinction, but stabilization occurs under persistently hazardous conditions.** Medical advances, migration, infrastructure and emergency interventions offset some of the damage without necessarily eliminating its underlying causes.

Stability is not safety

Stabilization sounds like good news. In ecological language, a system can have more than one stable state. A lake can be clear or turbid; a forest can be lush or degraded; each can persist for a long time. The research on [critical transitions](#) shows that once a system tips into the degraded state, **restoring the old conditions typically requires far more effort than preventing the shift**, because feedbacks now hold the new state in place.

Applied to global civilization, the degraded stable state has several defining properties:

- Population and economic output can be sustained or even grow, concentrated in protected enclaves and managed megacities.
- A large share of people live permanently with hazards that are normal rather than exceptional.
- Emergency management becomes a permanent function of government, absorbing a rising portion of resources.
- Technology offsets damage, for example through cooling, desalination, filtration and medicine, without removing causes.

A landscape of resilience

Figure 12 shows the idea of stability landscapes. In the first panel, the system sits in a deep basin: shocks displace it, and it returns. In the second, the basin has been eroded; it still holds, but small perturbations are enough to push the system around, and the resting state is unsafe. In the third, the recovery basin has been lost entirely.

Stability landscape of civilizational resilience (conceptual)

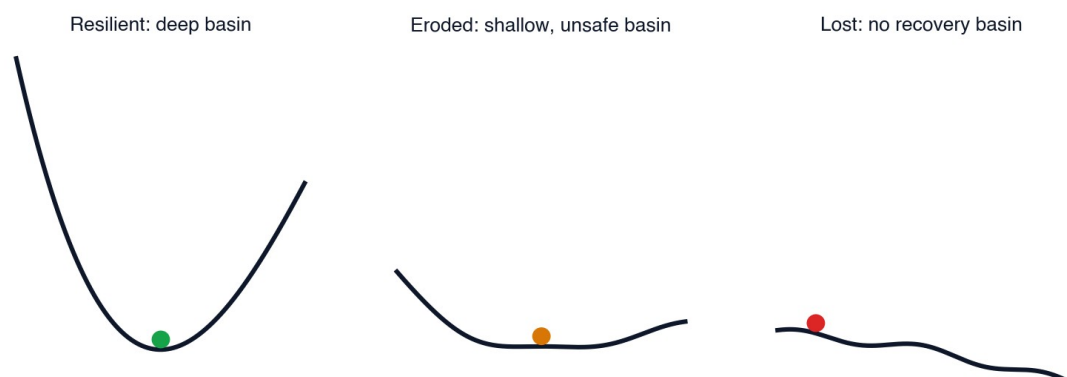


Figure 12. Conceptual stability landscape. Erosion of the basin represents loss of resilience, not necessarily loss of function.

The unequal geography of stabilization

A defining feature of an unsafe stabilization is its **uneven distribution**. Wealthy regions can fund seawalls, cooling, desalination and private security. Poorer regions cannot. The result is a world in which civilization continues, but in two or more speeds: enclaves of relative safety surrounded by large populations in chronic hazard. This pattern is consistent with the [safe and just boundaries](#) analysis, which finds that exposure to unsafe conditions is sharply unequal.

The adaptation ceiling

Adaptation is powerful but finite. The [IPCC](#) distinguishes soft limits (where options exist but are not yet available, often for financial or political reasons) from hard limits (where no adaptation is possible). Human thermal tolerance, the loss of coral reefs, and the disappearance of ice-dependent livelihoods are examples of approaching hard limits. In an unsafe stabilization, adaptation consumes ever more resources to hold the line, leaving less for transformation.

Compensating technology	What it offsets	What it leaves unresolved
Air conditioning and cooling	Heat exposure	Energy demand, waste heat, access inequality
Desalination and water reuse	Freshwater scarcity	Brine, energy cost, upstream depletion
Advanced medicine	Disease burden	Cost, resistance, root environmental causes
Seawalls and managed retreat	Coastal flooding	Cost, displacement, long-term sea-level commitment
Controlled-environment agriculture	Crop failure	Energy, scale, nutrient cycles

KEY INSIGHT *The most dangerous feature of a degraded stable state is that it feels stable. Its persistence reduces the political urgency for change, while its hidden costs accumulate.*

08 Feedback Loops and the Erosion of Resilience

Section 3 described how crises interact. This section examines the **feedback loops** that turn interaction into acceleration. A feedback loop is reinforcing when its output increases its own input. The Polycrisis Apocalypse is driven by several such loops operating at different speeds.

The core loop

The loop at the heart of the framework runs as follows. A crisis shock damages resilience (infrastructure, institutions, ecosystems, public health, trust). Reduced resilience raises vulnerability to the next shock. Responding to emergencies diverts money and attention from the long-term investments that would restore resilience. The recovery that was foregone leaves the system weaker for the next shock, and the loop closes.

The resilience-erosion feedback loop

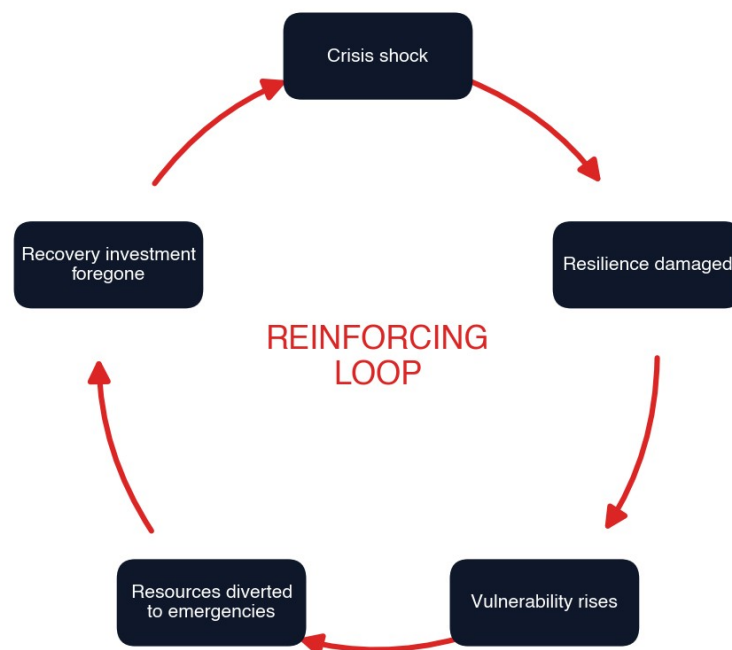


Figure 13. The resilience-erosion loop at the heart of the Polycrisis Apocalypse.

The recovery gap

The loop can be expressed as a simple race. If shocks arrive further apart than the time needed to recover, resilience rebuilds between them. If shocks arrive *closer together* than the recovery time, each one lands on a society that has not yet recovered from the last. Climate change shortens the

interval between extreme events while compound damage lengthens the recovery time. Figure 14 shows the moment at which the two curves cross.

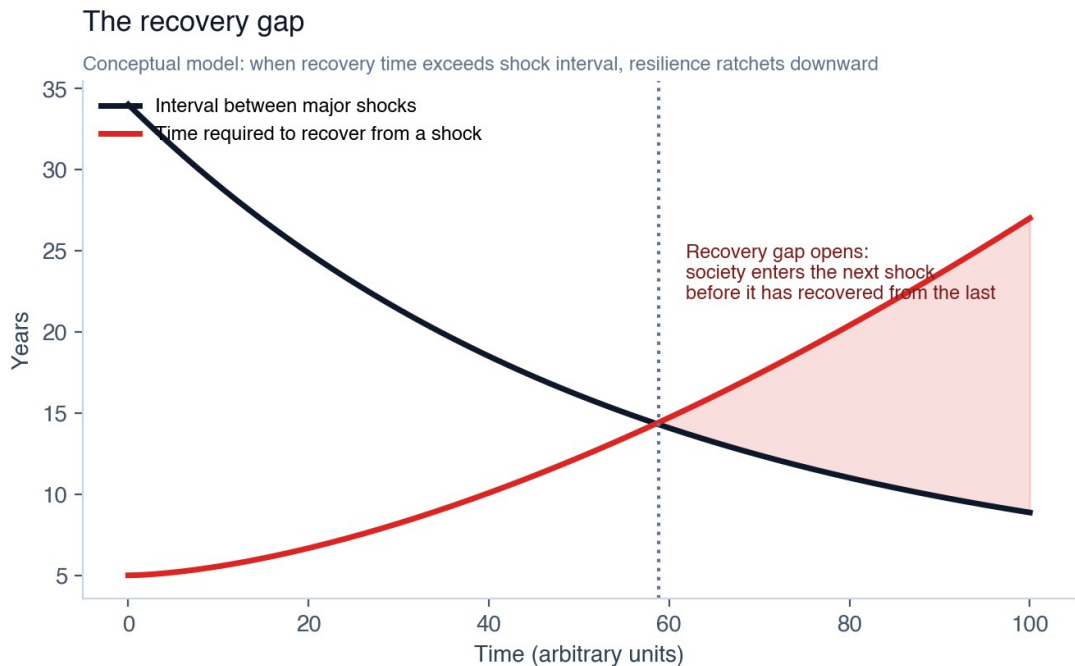


Figure 14. Conceptual model of the recovery gap. When recovery time exceeds shock interval, resilience ratchets downward.

Six reinforcing loops

Loop	How it reinforces
Climate–carbon	Warming thaws permafrost and weakens sinks, releasing more carbon. Tipping elements studied by Armstrong McKay et al. can interlock.
Poverty–environment	Poverty forces unsustainable resource use, degrading the land that poor communities rely on.
Conflict–capacity	Conflict destroys infrastructure and institutions, which makes later conflict more likely.
Fiscal–disaster	Disaster losses raise debt and insurance costs, reducing investment in prevention.
Trust–governance	Crises erode trust; low trust makes collective action harder, which worsens crises.
Complexity–fragility	Tainter’s thesis: rising complexity yields diminishing returns, leaving societies brittle.

Tipping dynamics

Some loops behave nonlinearly. The [Global Tipping Points Report](#) warns that several climate tipping elements, including warm-water coral reefs, the Greenland and West Antarctic ice sheets, North Atlantic circulation and abrupt permafrost thaw, are already at risk of being crossed at current

warming levels. Evidence on [AMOC stability](#) suggests a collapse could occur this century, though timing is uncertain. [Steffen et al.](#) caution that crossing such thresholds could trigger a cascade toward a “Hothouse Earth” pathway.

Why loops matter more than levels

A purely level-based analysis asks: how bad is each crisis today? A loop-based analysis asks: *which trends make the next crisis worse?* The second question is the one most relevant to a multi-century scenario, because small differences in loop gain, compounding over generations, can separate a recoverable world from an unrecoverable one.

09 Centuries: Inherited Damage and Chronic Risk

Stage four of the trajectory begins when the system has been stabilizing, or failing to stabilize, long enough that **societies inherit accumulated environmental damage, institutional weaknesses, and new technological or geopolitical threats**. Recovery may repeatedly occur without producing durable global safety, leaving civilization trapped in a chronic-risk state. On timescales of decades to centuries, the main drivers of this outcome are legacy systems.

The climate commitment

Even if emissions were halted, the climate system would continue to respond. The oceans take centuries to equilibrate, ice sheets respond over centuries to millennia, and carbon is removed from the atmosphere only slowly. Current policies point toward roughly 3°C of warming by 2100 ([UNEP Emissions Gap](#)). The [IPCC](#) is explicit that sea-level rise will continue for centuries to millennia, and that some changes, such as ice-sheet loss and ocean acidification, are irreversible on human timescales.

Compounding social inheritance

Environmental damage is only half of the inheritance. Each generation also inherits the institutions, debts, grievances and inequalities of the last. Chronic risk therefore accumulates in at least four forms.

Inheritance	Mechanism	Consequence for later generations
Environmental	Committed warming, depleted aquifers, eroded soils, lost biodiversity	Lower baseline productivity and habitability
Institutional	Weakened states, eroded trust, legacy of failed responses	Reduced capacity for coordination
Economic	Debt, stranded assets, underinvestment in public goods	Fewer resources for recovery
Technological	Proliferation of dangerous capabilities, hardening of surveillance and security states	Rising stakes of any single failure

The persistence of new geopolitical threats

A degraded world is also an *armed* world. Nuclear arsenals, advanced conventional weapons and cyber capabilities do not decay when economies weaken. In fact, scarcity and instability raise the incentive to use them. The [Bulletin of the Atomic Scientists](#) has moved the Doomsday Clock closer to midnight than at any time in its history. Analysis by [Xia et al. \(2022\)](#) estimates that a full-scale US–Russia nuclear war could produce soot injections large enough to put over five billion people at risk of starvation.

Recovery without safety

One of the most important features of this stage is the possibility of **recovery cycles**. A society can rebuild after a shock, regain output, and then be struck again by a shock to which it is now more vulnerable. History offers partial analogues. [Tainter](#) argues that complex societies collapse when the marginal return on complexity falls. Over centuries, repeated partial recoveries can ratchet the system into a lower plateau, much as repeated forest fires can convert a forest into scrubland.

A century-scale picture

The stylized century-scale picture of the Polycrisis Apocalypse therefore looks as follows:

- **Decades 1–30:** convergence peaks. Large populations enter risk regions. Emergency management becomes routine.
- **Decades 30–100:** unsafe stabilization. Enclaves of safety grow; chronic-risk regions persist. Population peaks around 10 billion in the [UN projections](#) and then declines or plateaus.
- **Centuries 2–5:** inherited damage dominates. Adaptive capacity is consumed by maintaining existing systems. Shocks from sea level, heat, conflict and pandemics recur.

KEY INSIGHT *Within a few centuries, the question is no longer whether the original crises were solved, but whether the legacy of those crises has become the permanent condition of life.*

10 Millennia: The Long Tail of Damage

On timescales of thousands of years, the dominant story shifts from social processes to **Earth-system inertia**. Many of the consequences of 21st-century activity unfold over periods longer than recorded human history. The long tail matters for this framework because it shows that a civilization cannot simply “wait out” the damage.

Carbon, climate and sea level

[Archer \(2009\)](#) showed that while a portion of emitted CO₂ is absorbed by the ocean within a few centuries, a substantial fraction, commonly cited as 20–35%, remains in the atmosphere for many millennia, with the final removal through rock weathering taking up to hundreds of thousands of years. [Clark et al. \(2016\)](#) concluded that decisions in this century set multi-millennial climate and sea-level outcomes, with the potential for many metres of sea-level rise as ice sheets respond.

A catalogue of persistence

Figure 15 compares the persistence of several categories of damage. On a log scale, the contrast between human political time (years to decades) and Earth-system time (millennia and beyond) becomes stark.

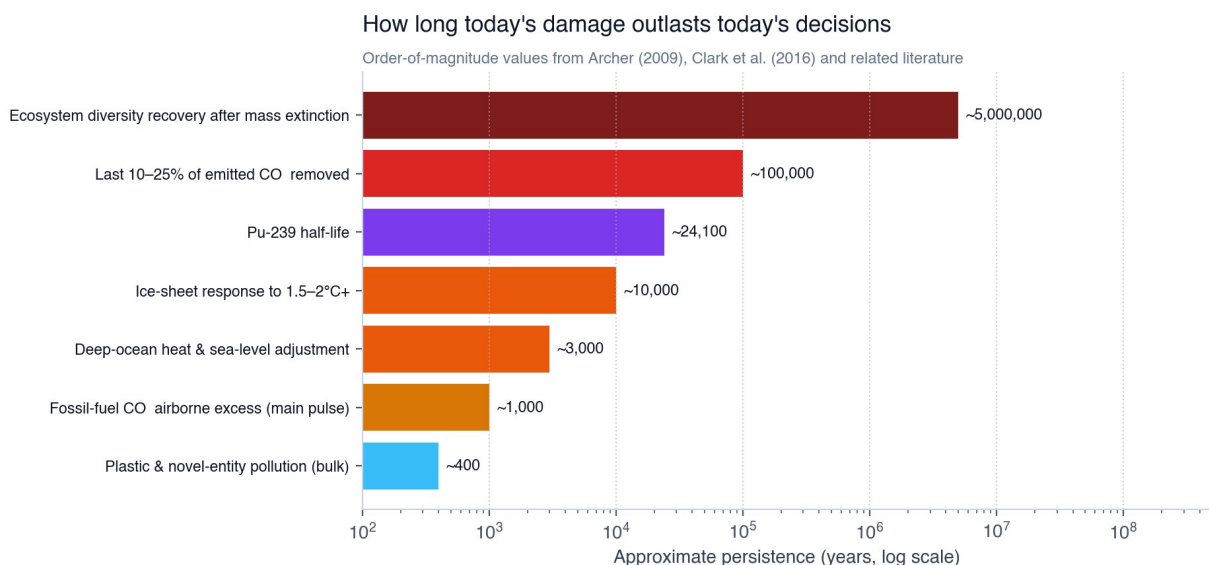


Figure 15. *Approximate persistence of legacy hazards (log scale). Values are order-of-magnitude estimates from the literature.*

Biodiversity: the million-year debt

Species lost today do not return on human timescales. Palaeontological evidence from past mass extinctions indicates that full recovery of biological diversity takes millions of years ([Kirchner and Weil, 2000](#)). The [IPBES](#) assessment of around one million threatened species, and the finding of [Ceballos et al.](#) that modern extinction rates far exceed background rates, together imply a

biodiversity deficit that no human generation will see repaid. Ecosystem services supplied by diversity, such as pollination, soil formation and pest control, would be correspondingly diminished.

Nuclear and chemical legacies

Some of the most persistent human-made hazards are not environmental in the usual sense. Plutonium-239 has a half-life of about 24,100 years. Persistent organic pollutants and PFAS “forever chemicals” are built to resist degradation. Radioactive waste stores, if societies fail to maintain them through collapse and recovery, become a **custodial burden across millennia**, one that depends on institutions lasting far longer than any in history.

The institutional mismatch

The central challenge of the millennial scale is a mismatch between hazard duration and institutional lifespan. The hazards persist for tens of thousands of years, while the longest-lived states and organizations persist for a few centuries. A civilization that must manage persistent hazards across multiple cycles of political collapse and renewal is operating at the limit of what human institutions have ever achieved.

Timescale	Dominant processes	What humans must manage
10 ² years	Ocean heat uptake, emissions legacy, institutional drift	Heat, sea level, political stability
10 ³ years	Ice-sheet response, ocean circulation, soil and aquifer recovery	Coastal retreat, agriculture relocation
10 ⁴ years	Carbon-cycle adjustment, long-lived waste	Custodial burden across civilizations
10 ⁵ years	Final CO ₂ removal, glacial timing	Climate timing, loss of baseline conditions

KEY INSIGHT *The millennial tail does not guarantee extinction. It guarantees that survivors inherit a changed planet whose management demands continuity that human institutions have never achieved.*

11 Deep Time: Tens to Hundreds of Thousands of Years

The framework's most speculative extension carries the scenario across tens to hundreds of thousands of years. This is longer than the entire history of *Homo sapiens*, whose oldest known fossils at [Jebel Irhoud](#) are around 300,000 years old. At such scales, forecasting gives way to structured imagination, and the honest posture is humility.

Deep-time timeline of lingering vulnerability

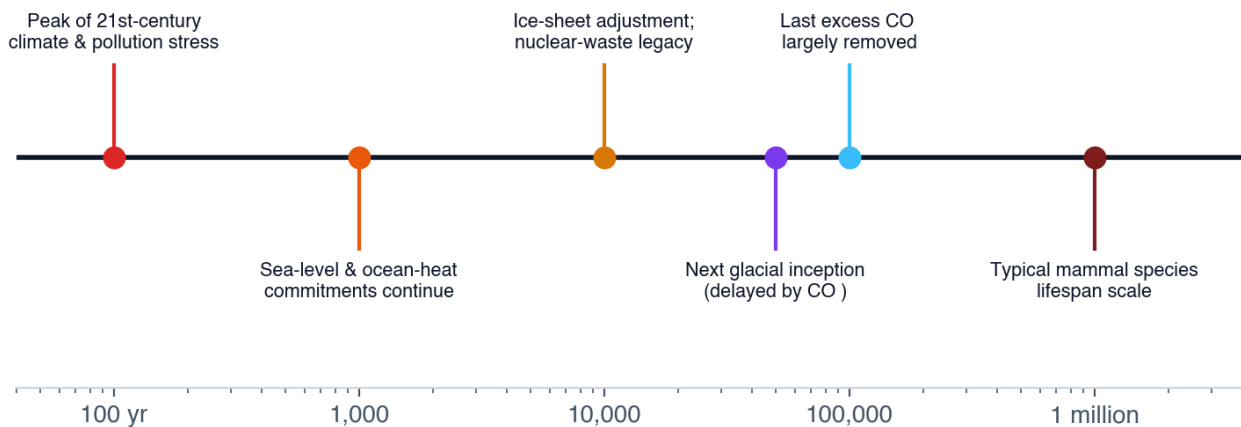


Figure 16. Deep-time timeline of lingering vulnerability (log scale). Positions are approximate.

What is plausibly still happening at 10^4 – 10^5 years

- **Climate system.** Excess CO₂ may still be elevated. [Ganopolski et al. \(2016\)](#) found that the next glacial inception could be delayed by 50,000 years or more if CO₂ remains high, so the glacial cycle itself is disrupted.
- **Sea level.** Ice-sheet adjustment would continue, and coastlines could be redrawn by tens of metres under the highest scenarios.
- **Biosphere.** Evolutionary recovery from a modern extinction event would be only beginning. Ecosystems would be reassembling.
- **Natural hazards.** Rare natural catastrophes accumulate. The [Toba eruption](#) about 74,000 years ago, whose effect on humanity remains debated, illustrates the scale of supervolcanic events that occur roughly once every tens of thousands of years.
- **Technological residue.** Any surviving civilization would carry, or be shaped by, the knowledge and artefacts of the earlier one.

The arithmetic of tail risk

Deep time turns small probabilities into large ones. If a civilization faces a one-in-a-thousand chance per century of an irrecoverable catastrophe, the probability of surviving 10,000 years (100 centuries) is about 90%. At one in a hundred per century, survival over the same span falls to about 37%. At 1 in 6 per century, as the aggregate expert estimate suggests for the current century, survival to 10,000 years would be effectively zero, *if* that risk level persisted.

Per-century risk	Survival to 1,000 yrs	Survival to 10,000 yrs	Survival to 100,000 yrs
1 in 10,000	99.9%	99.0%	90.5%
1 in 1,000	99.0%	90.5%	36.8%
1 in 100	90.4%	36.6%	0.004%
1 in 20	59.9%	0.6%	~0%
1 in 6	16.1%	~0%	~0%

The point of this table is the **logic of the long tail**, which is Toby Ord's central argument in [The Precipice](#): over a long enough horizon, survival depends less on the average level of risk than on whether risk can be driven to a very low, sustained level. A civilization trapped at moderate chronic risk will eventually fail; a civilization that escapes into very low risk can last for a very long time.

The pessimistic deep-time reading

In the pessimistic version of the framework, risk is *not* driven down. Degraded institutions cannot manage dangerous technologies, persistent hazards demand maintenance that collapsing states cannot provide, and each recovery fails to produce lasting safety. The system behaves as a **random walk with an absorbing barrier**: it wanders between worse and better states for tens of thousands of years, and the probability that it eventually hits the barrier approaches one.

The limits of the argument

The deep-time reading is a hypothetical terminal scenario, not an established prediction. Over such timescales the trajectory becomes extremely uncertain. Technological breakthroughs, ecological recovery, political transformation and changes in human settlement could substantially reduce risk. Humanity could also recover, change its relationship with the biosphere, expand beyond Earth, or encounter outcomes that this framework does not capture. The typical lifespan of a mammal species is on the order of one million years ([background extinction rates](#)), which provides one reference point, but humans are not a typical species.

KEY INSIGHT *Deep time does not show that extinction is predetermined. It shows that a civilization can remain vulnerable long after the initial catastrophe has passed, and that small, persistent risks accumulate.*

12 Terminal Pathways to Extinction

The fifth stage is the terminal outcome: **civilization's capacity to adapt falls below the pressures it faces**. Successive catastrophes, irreversible environmental changes or existential hazards eventually eliminate humanity's remaining capacity for recovery. This section catalogues the pathways by which that could happen.

Expert-judgment risk estimates

The most widely cited quantitative synthesis is Toby Ord's [The Precipice](#), which assigns probabilities to existential catastrophe over the 21st century. Ord's estimates are judgments, not measurements, and are contested. They are valuable mainly for their relative ordering: **anthropogenic risks dominate natural ones by orders of magnitude**.

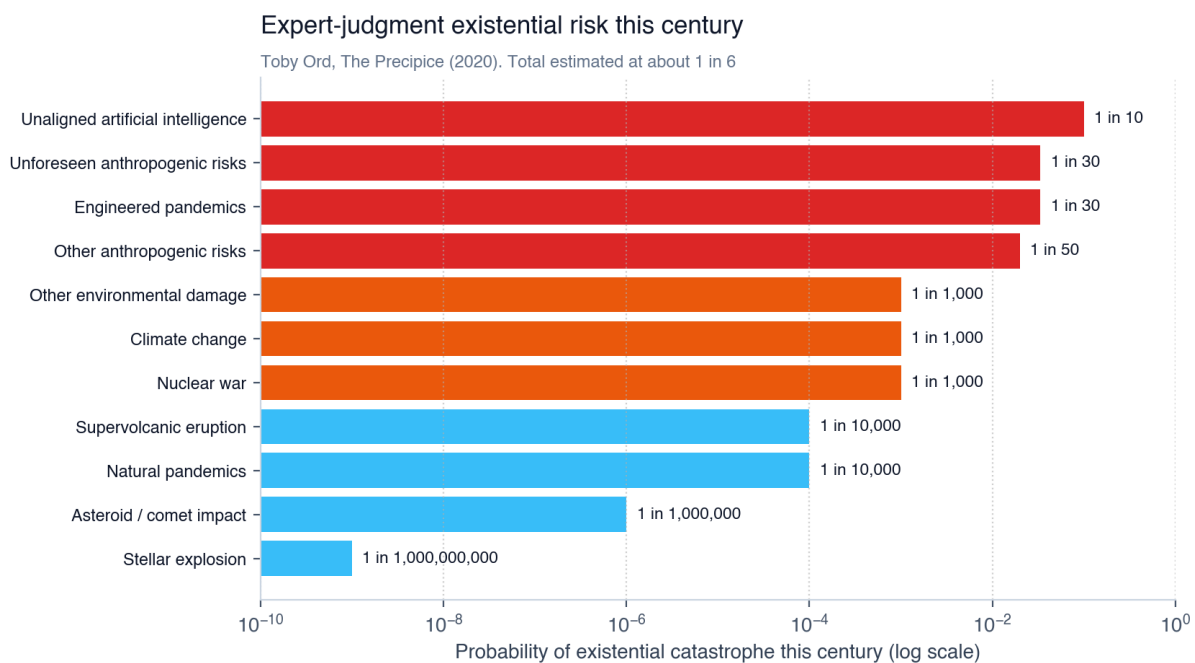


Figure 17. Estimated probability of existential catastrophe this century, by source. Source: Ord (2020), *The Precipice*.

Pathways relevant to a polycrisis world

Pathway	How a polycrisis raises the risk	Key reference
Nuclear war and nuclear winter	Resource conflict, state fragility, degraded command and control	Xia et al.
Engineered or natural pandemic	Crowded displacement, weak health systems, lab proliferation	Lancet AMR
Climate endgame / hothouse	Tipping cascades, failed mitigation, geoengineering conflict	Kemp et al.
Ecological collapse	Loss of pollination, soils, fisheries, food-web integrity	IPBES

Pathway	How a polycrisis raises the risk	Key reference
Misaligned or misused advanced AI	Security races among stressed states, weak governance	CSER
Unforeseen technologies	Reduced capacity to regulate and monitor	Bostrom
Natural events (supervolcano, impact)	Defence and response capacity eroded	Toba

Climate as a risk multiplier

[Kemp et al. \(2022\)](#) argue that the scientific community has underexplored catastrophic climate scenarios, including those in which warming above 3°C interacts with mass displacement, famine, conflict and pandemic. Climate change on its own is rated only modestly in Ord's tally, around 1 in 1,000, precisely because direct extinction from warming is difficult. Its larger role in the framework is as a **multiplier** that raises the odds of the anthropogenic pathways by removing the slack from every other system.

Combination scenarios

The most plausible terminal path is not a single cause but an **ordered combination**: a long period of chronic degradation, followed by a precipitating shock the weakened civilization cannot absorb. A representative sequence illustrates the idea.

- A century of unsafe stabilization leaves institutions hollowed out and security competition intense.
- A regional war between nuclear states, or a pandemic from an engineered or natural pathogen, produces a global shock.
- Agriculture and trade collapse in affected regions; survivors face a damaged biosphere and weakened infrastructure.
- A second, independent shock lands before recovery. The recovery gap of Section 8 is now unbridgeable.
- Population falls below the level needed to sustain technological civilization, and the capacity for recovery is lost.

Minimum viable population and the final decline

Even when civilization is lost, humans need not be. Small populations of hunter-gatherers could persist in refugia. Extinction requires a further stage in which small populations are lost to genetic, ecological or stochastic causes, or to a hazard that reaches refugia, such as persistently toxic or climatically hostile conditions. This is why the framework treats extinction as the *end* of a very long decline rather than a singular event.

KEY INSIGHT *The terminal pathway is dominated by hazards that humans create. The Polycrisis Apocalypse is dangerous precisely because it degrades humanity's ability to manage them.*

13 Scenario Architecture

This section organizes the trajectory into a set of scenario families. They are not forecasts. Their purpose is to show the qualitative shapes the framework distinguishes, so that readers can decide which shape the evidence most supports.

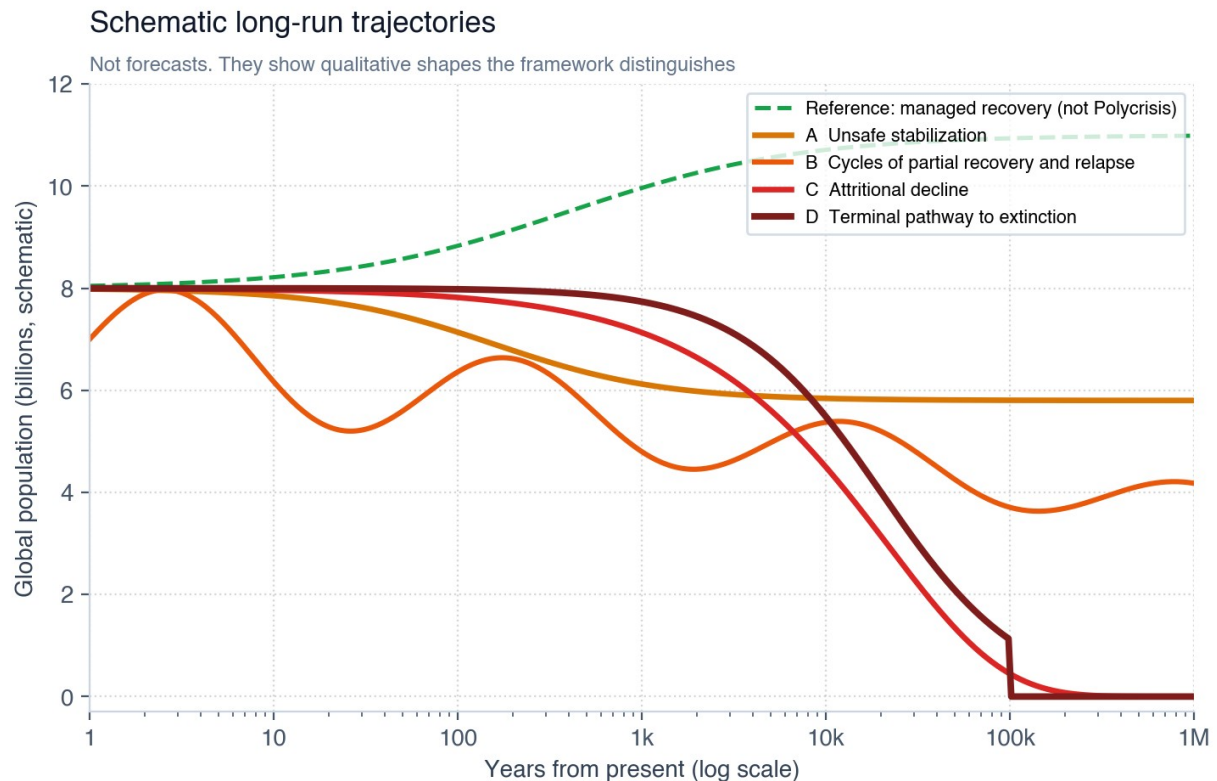


Figure 18. Schematic long-run trajectories of global population under four Polycrisis scenarios, against a managed-recovery reference. Log time axis.

Scenario A: unsafe stabilization

Population plateaus and then declines gently. Civilization persists with technologies of compensation. Hazards remain normal, and a large minority or majority lives in the high- or critical-risk tiers. The system does not collapse, but it also does not exit the risk envelope. This is the baseline *Polycrisis* scenario, and the one closest to the framework's title.

Scenario B: cycles of partial recovery and relapse

Societies repeatedly rebuild and relapse, with shocks arriving into incompletely repaired systems. Population oscillates with a downward drift. Records and institutions are lost and partially rediscovered. This scenario most resembles historical patterns of regional collapse, but across the globe and across much longer periods.

Scenario C: attritional decline

A persistent excess of mortality over births, driven by chronic disease, hunger, conflict and lower fertility, produces a slow, multi-millennial decline. There is no single event. The population gradually becomes too small and too dispersed to sustain complex technology, and the decline continues.

Scenario D: terminal pathway

Chronic degradation ends in an abrupt collapse caused by one of the anthropogenic or natural hazards in Section 12. Extinction follows within a few generations to a few thousand years. The timing is highly uncertain, which is why the figure shows it at tens of thousands of years.

Reference: managed recovery

The dashed green line shows what the framework is *contrasted with*: a world that uses the stabilization window to restore safe conditions. This path is not a Polycrisis Apocalypse. It is included as a reminder that the trajectory is conditional on failure of the response.

Scenario	Population shape	Risk exposure	Primary driver	Terminal?
A Unsafe stabilization	Plateau, slow decline	Chronic, majority high risk	Lock-in of hazard	No (indefinite)
B Cycles of relapse	Oscillating decline	Episodic acute risk	Recovery gap	Possible
C Attritional decline	Slow monotonic decline	Persistent mortality excess	Chronic disease, fertility, conflict	Eventually
D Terminal pathway	Abrupt collapse	Acute catastrophic risk	Anthropogenic or natural shock	Yes

Transition conditions

What moves a trajectory from one scenario to another? Four variables carry most of the weight.

- **Loop gain:** how strongly feedback loops reinforce degradation versus recovery.
- **Institutional continuity:** whether governance and knowledge survive shocks.
- **Dangerous-technology control:** whether weapons, pathogens and other tail risks are held to low, sustained levels.
- **Planetary margin:** how much slack the biosphere retains for recovery.

14 Counterarguments and Uncertainty

A report on a pessimistic scenario is only useful if it is honest about what could make the scenario wrong. This section sets out the strongest counterarguments and assesses how seriously each should be taken.

Counterargument 1: humanity is adaptable

Humans have colonized every climate zone, survived ice ages, and rebuilt after catastrophic wars. Technological progress has repeatedly reduced mortality: extreme poverty and child mortality have fallen dramatically over two centuries ([Our World in Data](#)). **Assessment:** this is the strongest counterargument, and it is the reason the framework emphasizes unsafe stabilization over immediate collapse. Adaptability supports survival, but it does not by itself show that survival will be *safe*, nor that adaptation can keep pace with a changing and increasingly interlinked risk set.

Counterargument 2: past doom forecasts failed

Predictions of Malthusian famine and resource exhaustion repeatedly proved premature. **Assessment:** valid as a caution about timing and confidence. But the polycrisis concern is not about a single resource running out. It is about **coupled systems** and irreversible thresholds, and some of the claimed past failures were averted precisely because societies acted, for instance in the case of the ozone layer.

Counterargument 3: technology will solve the hard problems

Clean energy costs have fallen sharply, and carbon removal, gene editing, AI and fusion may offer new tools. **Assessment:** plausible and important. Technology is the most credible route from unsafe stabilization to managed recovery. But technology is also the main source of the largest existential risks in Section 12, so it cuts both ways.

Counterargument 4: space and redundancy

A self-sustaining settlement off Earth would decouple some risks. **Assessment:** valuable as a long-term hedge, but not credible as a mitigation for risks arising within the next several centuries. A settlement dependent on Earth supply chains would be vulnerable to the same degradation.

Counterargument 5: expert estimates are unreliable

Existential-risk probabilities such as Ord’s are subjective, and critics argue they cannot be calibrated. **Assessment:** fair. This report uses them as ordinal guidance rather than precise values.

Source of uncertainty	Direction	Reducible?
Climate sensitivity and tipping thresholds	Both (risk skewed to the upside)	Partly, through observation
Social and political response	Both	Yes, through decisions

Source of uncertainty	Direction	Reducible?
Technological breakthroughs	Both	Partly, through governance
Long-run fertility and demography	Both	Partly
Probability of extreme tail events	Mostly upward	Weakly
Deep-time unknowns	Unknown	No

BALANCED ASSESSMENT *The framework survives the counterarguments in a weakened but not discredited form. The case for unsafe stabilization is strong; the case for terminal extinction is a low-probability, high-consequence tail. Both deserve attention because the consequences are asymmetric.*

Why pessimism can still be rational

Risk management often focuses on worst-case plausible scenarios because the cost of being wrong is not symmetric. If the pessimistic scenario is wrong and precautions were taken, the cost is the price of those precautions. If it is right and no precautions were taken, the cost is irreversible. This asymmetry is the logic behind the precautionary principle in existential-risk research ([CSER](#), [Bostrom](#)).

15 Indicators and Early Warning

If the Polycrisis Apocalypse is a trajectory, it should leave measurable signatures. This section proposes an indicator dashboard organized around the five stages. The aim is to detect whether the world is moving toward unsafe stabilization or away from it.

Stage 1–2 indicators: convergence and expansion

Indicator	Direction of concern	Data source
Planetary boundaries transgressed	Rising count (now 6 of 9)	Stockholm Resilience Centre
Global mean temperature anomaly	Exceeding 1.5°C long-term	Copernicus
Number of tipping elements at risk	Rising	Global Tipping Points
People in food crisis or worse	Rising	FAO SOFI
People exposed to dangerous heat	Rising	Lancet Countdown
Pollution-attributable deaths	Not falling	Lancet Commission
Forcibly displaced people	Rising	UNHCR
Share in extreme poverty	Stalling or reversing	World Bank

Stage 3 indicators: unsafe stabilization

- Persistent emergency expenditure as a share of public budgets.
- Widening gap in life expectancy and hazard exposure between regions.
- Rising reliance on compensating technologies without parallel reduction of root causes.
- Adaptation limits reached: coral loss, thermal-tolerance exceedance, abandoned settlements.

Stage 4–5 indicators: persistence and terminal risk

Indicator	Why it matters
Time between major systemic shocks vs. recovery time	Direct measure of the recovery gap
Nuclear arsenal size and posture	Governs the largest single-event catastrophic risk (SIPRI)
Biosecurity capacity and pathogen surveillance	Governs pandemic tail risk
Governance of frontier AI	Governs risk of technological loss of control or misuse
Trust in institutions and rates of state fragility	Predictors of collective-action capacity
Atmospheric CO ₂ trend and carbon-removal scale	Controls the millennial climate burden
Rate of species extinction	Controls the biodiversity debt

A composite dashboard

A simple way to summarize the indicators is a traffic-light dashboard, updated annually. The status values below reflect H Heuristics' reading of the cited sources as of the report date and are meant as a starting point for discussion, not a definitive assessment.

Stage	Dimension	Status	Trend
1 Convergence	Planetary boundaries	RED	Worsening
1 Convergence	Climate trajectory	RED	Worsening
2 Expansion	Food and water security	AMBER-RED	Stagnant
2 Expansion	Pollution burden	RED	Slowly improving in some regions
2 Expansion	Displacement and conflict	RED	Worsening
3 Stabilization	Adaptation capacity	AMBER	Uneven
4 Persistence	Institutional resilience	AMBER	Uncertain
5 Terminal	Tail-risk governance	RED	Worsening

KEY INSIGHT *No single indicator signals the Polycrisis Apocalypse. The signature is simultaneity and persistence: multiple indicators worsening together, for long enough that recovery becomes the exception.*

16 Implications: Breaking the Trajectory

A pessimistic framework is useful only if it clarifies where intervention has leverage. This section translates the preceding analysis into implications for policy, institutions, business and research. The purpose is not to prescribe a program, but to identify the points at which the trajectory is most sensitive.

Principle 1: prevent lock-in, not just damage

The distinctive danger of the framework is *persistence*. Policy should therefore weigh irreversibility heavily. Actions that avoid thresholds, such as the loss of ice sheets, species or institutions, have value beyond their immediate benefits because they preserve optionality. The IPCC's [Synthesis Report](#) underlines that near-term choices determine long-term outcomes.

Principle 2: reduce exposure where hazard and vulnerability overlap

The envelope is highest where heat, pollution, poverty, conflict and weak institutions coincide. Targeted investment in these *hotspots* (health systems, clean water, cooling, early warning, social protection) reduces survivability risk faster per dollar than diffuse spending.

Principle 3: close the recovery gap

If the central mechanism is shock interval falling below recovery time, then two levers matter: lengthen the interval, by mitigating hazards, and shorten recovery, by pre-positioning capacity, financial buffers and redundancy. Resilience investment is the primary tool for the second lever.

Principle 4: govern the tail risks

Because anthropogenic technologies dominate existential risk, governance of nuclear weapons, biosecurity and advanced AI has disproportionate leverage on the terminal outcome. These are the areas in which international coordination is most valuable and most fragile.

Principle 5: build institutions for long timescales

The millennial mismatch of Section 10 argues for institutions designed for continuity: durable record-keeping, intergenerational trusts, and legal standing for future generations. Even modest improvements in institutional longevity have outsized effects on whether legacy hazards are managed.

Actor	Leverage point	Illustrative action
Governments	Mitigation, hotspot resilience, tail-risk governance	Phase out fossil fuels; fund adaptation; treaty on biosecurity and AI
Multilateral bodies	Coordination, finance, standards	Loss-and-damage finance; pandemic preparedness; arms control

Actor	Leverage point	Illustrative action
Business and finance	Capital allocation, supply chains	Price systemic risk; invest in resilient infrastructure
Researchers	Evidence, early warning	Study compound events and tipping cascades; monitor indicators
Civil society	Accountability, adaptation at community level	Local resilience, mutual aid, transparency
Individuals	Consumption, voting, careers	Support long-horizon policy; build local capacity

What would count as an exit?

An exit from the Polycrisis Apocalypse would be visible as a combination of: declining exposure in the highest-risk regions; rising institutional durability; falling per-century tail risk from weapons and pathogens; and stabilization of the Earth system at a safe level. Importantly, it requires *reducing* risk rather than merely relocating it.

KEY INSIGHT *The trajectory is conditional. Each stage has a window during which intervention is far cheaper than later. The earliest windows, in Stages 1 and 2, are the ones that are open now.*

17 Conclusion

The Polycrisis Apocalypse is an unfamiliar kind of catastrophe. It has no single moment, no clear villain and no obvious day on which it begins. It is a long narrowing of the margin for survival, in which converging crises push a growing share of humanity into survivability risk regions, civilization stabilizes at unsafe levels, damage and fragility accumulate over centuries and millennia, and, in the most severe scenario, a final shock arrives to a civilization too weakened to absorb it.

What this report has argued

- **Survival is not sustainable survival.** A civilization can persist while the underlying crisis goes unresolved.
- **The baseline is already alarming.** Billions of people already live with part of the survivability risk envelope.
- **Feedback loops convert interaction into acceleration.** The recovery gap is the key mechanism.
- **Damage outlasts decisions** by centuries, millennia and in some cases hundreds of thousands of years.
- **Tail risks dominate the long horizon.** Small, persistent per-century risks compound over deep time.
- **Extinction is a hypothetical terminal scenario, not an established prediction.** Humanity retains a very large capacity for adaptation and surprise.

The significance of the deep-time perspective

The significance of the deep-time perspective is not that extinction is predetermined. It is that a civilization can remain vulnerable long after the initial catastrophe has passed. That shifts the question from “will we survive the next crisis?” to “will we ever leave the zone in which every crisis could be the last?” Answering the second question requires more than passing through a bad century. It requires building a civilization whose risk, per century, is brought and held very low.

Closing assessment

The honest conclusion of a pessimistic scenario is not despair. It is a more precise form of urgency. The Polycrisis Apocalypse is a failure mode of *response*, not a law of nature. Its early stages are measurable, its mechanisms are understood in outline, and its windows for intervention are still open. The worst version of the future is neither inevitable nor remote, and it is made more likely by every delay that lets convergence harden into lock-in.

FINAL THOUGHT *A world can survive and still be losing. The task is to ensure that survival also means safety, and that the generations who inherit the Earth inherit a margin, not merely a remnant.*

A Appendix A: Glossary

Term	Definition
Anthropogenic risk	A threat arising from human activity or technology, as opposed to natural events
Compounding hazards	Simultaneous or sequential hazards whose combined effect exceeds the sum of the parts
Crisis convergence	The interaction of climate, pollution, poverty, conflict, ecological and institutional crises
Existential risk	A risk that threatens the extinction of humanity or the permanent destruction of its long-term potential
Feedback loop	A circular causal chain in which an output reinforces (positive) or dampens (negative) its own input
Planetary boundaries	Nine Earth-system processes whose limits define a safe operating space for humanity
Polycrisis	A cluster of related crises whose interactions produce harm greater than any crisis alone
Recovery gap	The condition in which recovery time exceeds the interval between shocks
Resilience	The capacity of a system to absorb shocks and return to function
Survivability risk envelope	The conceptual space in which populations face conditions that compromise survival or stable societies
Tipping element	A component of the Earth system that can shift abruptly and irreversibly past a threshold
Unsafe stabilization	A stable state in which civilization persists but around chronic, normalized hazard

B Appendix B: Sources and Further Reading

All links were selected for authority and stability (peer-reviewed journals, UN and intergovernmental agencies, and established research institutes). Where a figure in this report is illustrative, it is labelled as such.

Climate and Earth system

- [IPCC Sixth Assessment Report, Synthesis Report](#)
- [UNEP Emissions Gap Report 2024](#)
- [Richardson et al. \(2023\), Earth beyond six of nine planetary boundaries](#)
- [Rockström et al. \(2023\), Safe and just Earth system boundaries](#)
- [Armstrong McKay et al. \(2022\), Exceeding 1.5°C global warming could trigger multiple climate tipping points](#)
- [Global Tipping Points Report 2023](#)
- [Steffen et al. \(2018\), Trajectories of the Earth System in the Anthropocene](#)
- [Ditlevsen and Ditlevsen \(2023\), Warning of a forthcoming collapse of the AMOC](#)
- [Archer \(2009\), Atmospheric lifetime of fossil fuel carbon dioxide](#)
- [Clark et al. \(2016\), Consequences of twenty-first-century policy for multi-millennial climate and sea-level change](#)
- [Ganopolski et al. \(2016\), Critical insolation–CO₂ relation for diagnosing past and future glacial inception](#)
- [Xu et al. \(2020\), Future of the human climate niche](#)
- [Raymond et al. \(2020\), The emergence of heat and humidity too severe for human tolerance](#)
- [Mora et al. \(2017\), Global risk of deadly heat](#)
- [Lancet Countdown on Health and Climate Change](#)

Pollution, health, poverty and conflict

- [Fuller et al. \(2022\), Pollution and health, Lancet Planetary Health](#)
- [WHO, Ambient \(outdoor\) air quality and health](#)
- [Persson et al. \(2022\), Outside the safe operating space of the planetary boundary for novel entities](#)
- [FAO, State of Food Security and Nutrition in the World](#)
- [World Bank, Poverty overview](#)
- [UNHCR, Global Trends](#)
- [Lancet \(2024\), Global burden of bacterial antimicrobial resistance 1990–2021 with forecasts to 2050](#)
- [UN World Population Prospects](#)
- [IPCC AR6 Working Group II, Impacts, Adaptation and Vulnerability](#)
- [WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene](#)
- [Air Quality Life Index, University of Chicago EPIC](#)
- [ICIMOD, Hindu Kush Himalaya Assessment](#)
- [Our World in Data, Who has contributed most to global CO₂ emissions?](#)
- [UNEP Adaptation Gap Report 2023](#)
- [UNDP/OPHI, Global Multidimensional Poverty Index 2025: Overlapping Hardships](#)
- [Rentschler et al. \(2022\), Flood exposure and poverty in 188 countries](#)
- [Mekonnen and Hoekstra \(2016\), Four billion people facing severe water scarcity](#)
- [Lenton et al. \(2023\), Quantifying the human cost of global warming](#)
- [Tracking SDG 7: The Energy Progress Report](#)

- [World Bank, Groundswell: climate change could force 216 million people to migrate within their own countries by 2050](#)
- [Our World in Data](#)

Polycrisis, collapse and existential risk

- [Tooze, Welcome to the world of the polycrisis, Financial Times](#)
- [Cascade Institute](#)
- [Lawrence et al., Global polycrisis: the causal mechanisms of crisis entanglement](#)
- [Homer-Dixon et al. \(2015\), Synchronous failure](#)
- [Scheffer et al. \(2009\), Early-warning signals for critical transitions](#)
- [Tainter, The Collapse of Complex Societies](#)
- [Kemp et al. \(2022\), Climate Endgame](#)
- [Ord, The Precipice](#)
- [Bostrom, Existential risks](#)
- [Centre for the Study of Existential Risk](#)
- [Xia et al. \(2022\), Global food insecurity and famine from reduced crop, marine fishery and livestock production due to climate disruption from nuclear war soot injection](#)
- [Bulletin of the Atomic Scientists, Doomsday Clock](#)
- [SIPRI](#)
- [IPBES Global Assessment](#)
- [Ceballos et al. \(2017\), Biological annihilation via the ongoing sixth mass extinction](#)
- [Kirchner and Weil \(2000\), Delayed biological recovery from extinctions throughout the fossil record](#)
- [Hublin et al. \(2017\), New fossils from Jebel Irhoud](#)
- [Youngest Toba eruption](#)
- [Background extinction rate](#)

C Appendix C: Methodology and Limitations

This report is a **synthesis and scenario analysis**, not a quantitative forecast. It combines (1) published statistics from intergovernmental and academic sources, (2) conceptual models developed to illustrate mechanisms, and (3) structured scenario reasoning across timescales.

Data and illustration

- **Sourced data:** Figures 4, 5, 7, 10, 11, 15 and 17 draw on the cited sources and rounded values. Categories in Figure 5 overlap and should not be added together.
- **Illustrative models:** the 2050 and 2100 exposure ranges and regional stressor heat map in Section 6 (H Heuristics syntheses of published indicators), the interaction matrix, tier-drift chart, scenario trajectories, stability landscape, recovery-gap chart and feedback diagram are conceptual. They show shape and logic, not measured quantities.
- **Expert judgment:** Ord's probabilities are subjective estimates and carry deep uncertainty.

Known limitations

- Deep-time (10^4 – 10^6 year) reasoning is extrapolative and cannot be validated.
- The framework emphasizes downside scenarios by design; it does not assign probabilities to recovery.
- Source values (for example, population exposed, species threatened, and mortality attributions) are updated regularly. Readers should consult the linked sources for the latest figures.
- Hyperlinks reflect availability at the time of writing.

DISCLAIMER *This document is a research and educational overview prepared by H Heuristics. It does not constitute investment, policy or scientific advice, and it does not claim that human extinction is predicted or inevitable.*