

H HEURISTICS

Navigating a Changing World

Human Survival in the Polycrisis Century

Exposure, Vulnerability, and Risk Reduction From 2025–2100

How many people the entangled crises of the century could kill, who is most exposed and vulnerable, and how much of the toll is avoidable: measured evidence, a transparent scenario model and an honest account of the catastrophic tail

H Heuristics · Hunter Hughes

Research Report · October 2026

Abstract

Whether humanity will survive the century is really three questions: how many people will die of causes that can be prevented, whether correlated shocks could break the systems that keep most people alive, and whether any combination of hazards could end the species. This report keeps the three apart, measures the first, bounds the second and summarises the evidence on the third. It frames risk as hazard multiplied by exposure and vulnerability and divided by capacity, and it asks how each term evolves between 2025 and 2100 in a polycrisis, a world in which crises in several systems are causally entangled.

Part one assembles the measured baseline. Air pollution is linked to about 7.9 million deaths a year, unsafe water to about 1.4 million, antimicrobial resistance to about 1.1 million, heat to about 546,000 and organised violence to about 245,000, while reported disasters killed about 17,000 people in 2025. Warming is on course for between about 1.9 and 2.8 degrees by 2100; about 60 million people already face dangerous annual heat and about 2 billion would at 2.7 degrees; the population will peak near 10.3 billion in the 2080s, with people aged 65 and over outnumbering children by 2080 and about a third of humanity living in sub-Saharan Africa. Bangladesh shows that vulnerability can fall quickly: cyclone deaths fell from hundreds of thousands in 1970 to fewer than thirty in 2020.

Part two builds the Survival Exposure–Vulnerability Model, an accounting model with 20,000 Monte Carlo draws over six pathways and three worlds. About 12.8 million deaths a year are attributable to these stressors today. Cumulative attributable deaths to 2100 are about 757 million (10th to 90th percentile: 658 to 862 million) in a mobilised world, 1.14 billion (1.05 to 1.23 billion) on a muddling-through path and 1.55 billion (1.45 to 1.66 billion) in a drifting world. Mobilisation avoids about 380 million deaths relative to muddling through and about 790 million relative to drift, more than half of them through cleaner air; about 540 million come from reducing hazards and about 360 million from reducing vulnerability, with overlap. Ageing alone adds about 490 million deaths to the drifting world. A ten-year delay costs about 140 million lives. The ranking of worlds is robust to every variation tested; the size of the gaps is not.

The catastrophic tail cannot be modelled in the same way. In a 2022 forecasting tournament, domain experts gave a 6 per cent chance of human extinction and a 20 per cent chance of a catastrophe killing a tenth of humanity by 2100, and superforecasters 1 and 9 per cent. Weapons and pathogens, not climate change, dominate the tail, and the governing institutions are weakening: New START lapsed in February 2026, the pandemic agreement's pathogen-sharing annex is unfinished, and aid fell 23 per cent in real terms in 2025. The report concludes that the century's survival problem is mostly chronic, mostly avoidable and mostly decided by delivery, and proposes eight priorities and a thirteen-indicator survival dashboard.

Keywords: human survival; polycrisis; mortality risk; exposure and vulnerability; climate change; air pollution; heat; antimicrobial resistance; early warning; population ageing; catastrophic risk; existential risk; scenario modelling; Monte Carlo

JEL classification: Q54, Q56, I15, I18, J11, D81; climate and natural disasters; environment and development; health and economic development; public health; demographic trends; decision-making under uncertainty

Data and method: This report synthesises primary and authoritative secondary sources through October 2026; every quantitative claim about the world is linked inline. Figures 3, 5, 6, 7, 17, 18 and 19 report values from cited sources (population shares in Figures 6 and 7 are anchored on published UN figures, with the 2024 sub-Saharan Africa value derived; Figure 18 also shows model outputs), Figures 1, 2, 8, 9 and 20 are conceptual schematics or qualitative assessments, Figure 4 combines published estimates with model paths, and Figures 10 to 16 are outputs of the Survival Exposure–Vulnerability Model, an illustrative accounting model whose parameters and equations are given in Appendix A. Several sources were read through secondary summaries, as noted in the text. The report is analytical rather than predictive and contains no investment advice.

Contents

1. Introduction: Survival Is Not One Question.....	4
2. Framework: Exposure, Vulnerability and Mortality Risk	6
3. The Baseline: Who Dies Now, and Why.....	8
4. Hazard Trajectories to 2100.....	11
5. Exposure: A Larger, Older, More Urban World.....	15
6. Vulnerability: Where Harm Lands	17
7. Pathways and Cascades	19
8. The Survival Exposure–Vulnerability Model.....	22
9. Results: Mortality Under Three Worlds	24
10. The Catastrophic Tail	31
11. What Reduces Risk: An Evidence-Ranked Portfolio	35
12. Governance, Finance and the Delivery Problem	38
13. A Strategic Pathway, 2025 to 2100	40
14. Conclusions and Priorities	42
Appendix A. Model Specification	44
Appendix B. Sources by Theme	46

1. Introduction: Survival Is Not One Question

Asked whether humanity will survive the century, most people picture a single cliff edge. The evidence describes something different: a mountain range of risks of very different heights. At the foot is a large, measurable and mostly preventable toll of deaths that is happening now; at the summit is an extinction-level tail that nobody can measure. This report treats the two ends with the same discipline, and argues that the foot of the mountain is where most of the lives are.

1.1 Three meanings of survival

The word survival hides three questions. The first is about individuals: how many people will die, and how many of those deaths could be prevented, in a century that combines a warming climate, a polluted atmosphere, an ageing and growing population, fragile health systems and a rising number of armed conflicts. The second is about societies: whether shocks could become large and correlated enough to cause a collapse of food, health or governing systems that kills a tenth or more of humanity within a few years. The third is about the species: whether any combination of hazards could end the human story altogether.

These questions are routinely run together, and the result is bad analysis in both directions. Treating the century as a countdown to extinction wastes attention on a tail that evidence cannot yet size, while the measurable burden grows. Treating climate and pollution as an inconvenience for the economy ignores that, on current numbers, the atmosphere already attributes [about 7.9 million deaths a year to air pollution](#) and [about 546,000 a year to heat](#). This report keeps the three tiers apart (Figure 2), measures the first, bounds the second and states honestly what is known about the third.

1.2 Why the polycrisis frame matters for survival

Researchers at the Cascade Institute define a [global polycrisis](#) as a situation in which crises in several global systems become causally entangled, so that the harm of the whole exceeds the sum of the parts ([Lawrence et al., 2024](#)). The World Economic Forum's [Global Risks Report 2026](#) is consistent with that framing. For survival the practical implication is that mortality is not delivered by a single hazard with a single remedy. A drought becomes a hunger death through food prices, debt, conflict and a failed clinic. A heatwave kills more where the power grid, the health service and the housing stock are weak. The pathways are shared, and so are the remedies.

The year 2026 has supplied a live demonstration. In the first half of 2026 the US–Russia New START treaty [expired with no successor](#), official development assistance [recorded its largest fall on record](#), and a disruption of shipping through the Strait of Hormuz led the FAO to warn that [a prolonged closure could become a global agrifood catastrophe](#). Each is a different system; each touches the same people.

1.3 Headline findings

- **The measurable toll is large and mostly chronic.** In the report's accounting, about 12.8 million deaths a year are attributable today to six overlapping stressors: air pollution, heat, hunger and infection, extreme events, conflict and antimicrobial resistance. Air pollution is about 60 per cent of that total; disasters, the events that dominate headlines, are well under 1 per cent (Section 3).
- **Climate warming is real but is not the only driver, and not the largest lever.** Warming paths of roughly 1.9, 2.4 and 2.9 degrees Celsius by 2100 are compared with improvements in air

quality, health systems and early warning. Cumulative stressor-attributable deaths between 2025 and 2100 are about 760 million in a mobilised world, 1.14 billion on a muddling-through trajectory and 1.55 billion in a drifting world (Section 9).

- **Vulnerability is as important as hazard.** Of the gap between the best and worst worlds, about 540 million deaths are avoidable through the hazard side (cleaner air, lower warming, less conflict) and about 360 million through the vulnerability side (health care, heat adaptation, early warning, social protection); the two overlap, and together they account for about 800 million. Population ageing alone adds about 490 million deaths to the drifting world (Section 9).
- **Delay is expensive.** A ten-year delay in launching the mobilised pathway adds about 140 million deaths by 2100, or about 14 million for each year of waiting (Section 9).
- **The catastrophic tail is real and unmeasured.** The median expert in a 2022 forecasting tournament gave a 6 per cent chance of human extinction by 2100, and superforecasters 1 per cent; the same groups gave 20 and 9 per cent chances of a catastrophe killing a tenth of humanity. Nuclear war and engineered pathogens, not climate change, dominate the tail in most expert assessments (Section 10).
- **Delivery is the binding constraint.** International adaptation finance of about US\$26 billion a year compares with estimated needs of US\$310 to 365 billion by 2035, while aid fell 23 per cent in real terms in 2025 (Section 12).

1.4 How to read this report

The report is organised in four movements. Sections 2 and 3 define the framework and establish the baseline. Sections 4 to 7 trace hazards, exposure, vulnerability and the pathways that connect them. Sections 8 and 9 build and report a transparent scenario model, the Survival Exposure–Vulnerability Model, and Section 10 handles the catastrophic tail separately because it cannot be modelled in the same way. Sections 11 to 14 turn to risk reduction, finance and governance, a pathway to 2100 and priorities. Every quantitative claim about the world is linked to its source. The model is an argument about orders of magnitude, not a forecast, and its parameters are given in Appendix A.

Table 1. Evidence grades used throughout the report

Grade	Meaning	Examples in this report
A	Measured outcomes recorded in databases or surveys	Air-pollution deaths (HEI); under-five deaths (UN IGME); conflict deaths (UCDP); disaster deaths (EM-DAT); hunger counts (SOFI)
B	Modelled from measured data, or evaluated interventions	Heat deaths (Lancet Countdown); antimicrobial-resistance deaths (GRAM); Ahmedabad heat plan; Bangladesh cyclone warning
C	Third-party scenario models and expert elicitation	Mortality cost of carbon; human climate niche; nuclear-winter famine; forecasting-tournament probabilities
D	H Heuristics illustrative model	Survival Exposure–Vulnerability Model: Figures 10 to 16 and Tables 4 and 5

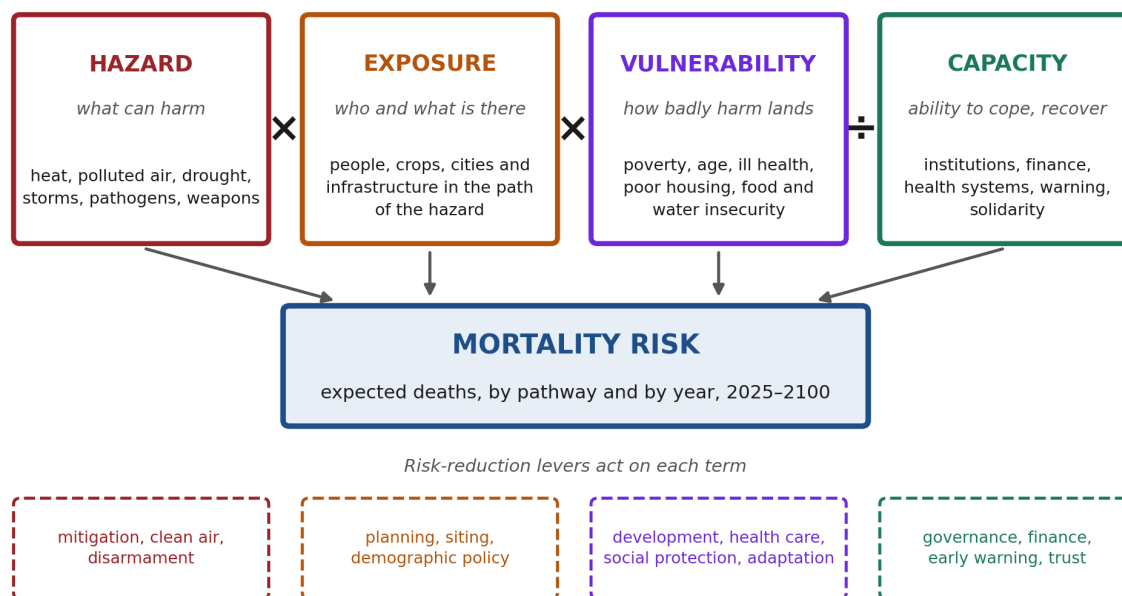
Every figure in the report states its grade or source in the caption line. Grade D outputs are conditional on the stated assumptions and are not forecasts.

2. Framework: Exposure, Vulnerability and Mortality Risk

A hazard does not kill anyone on its own. It kills when it meets people who are in its path and unable to protect themselves. The disaster-risk and climate-impact literatures converge on that insight, and it is the right place to start for a century-long question.

2.1 The risk equation

The report uses the standard decomposition of risk. Mortality risk is a function of the *hazard* (the physical or biological threat), the *exposure* (the people and assets in its path), the *vulnerability* (their susceptibility to harm if hit) and the *capacity* (the institutional, financial and social ability to cope and recover). The [IPCC's sixth assessment](#) frames climate risk in the same way, and finds that between 3.3 and 3.6 billion people live in contexts that are highly vulnerable to climate change.



In a polycrisis the terms are coupled: a shock to one weakens the others (Figure 8).

Figure 1. The framework: mortality risk as hazard multiplied by exposure and vulnerability, divided by capacity. Each term has its own levers.

Source: H Heuristics, adapted from the IPCC AR6 risk framing. Conceptual schematic.

The decomposition has a practical consequence. The four terms move at very different speeds and are governed by different institutions. Hazards depend on emissions and on the physical response of the earth system, which is slow and largely irreversible on human timescales. Exposure follows demography and settlement, which are slow but predictable. Vulnerability and capacity can change within a decade, as the cyclone record in Section 6 shows. A report concerned with survival over 75 years therefore has to ask not only how fast hazards grow, but how much vulnerability can be reduced while they do.

2.2 Three tiers of survival

The report organises outcomes into three tiers (Figure 2). Tier I is mass preventable mortality: the deaths from air pollution, heat, hunger, infection, conflict and disaster that already occur and will scale with population and ageing. The evidence base is strong for the present, moderate to mid-century and weaker thereafter. Tier II is civilisational disruption, defined following the 2022 forecasting tournament as a loss of at least 10 per cent of the global population within five years. Tier III is extinction, or a fall below 5,000 people. The evidence for Tiers II and III is expert judgement, supplemented by narrow scenario studies such as nuclear-winter models.

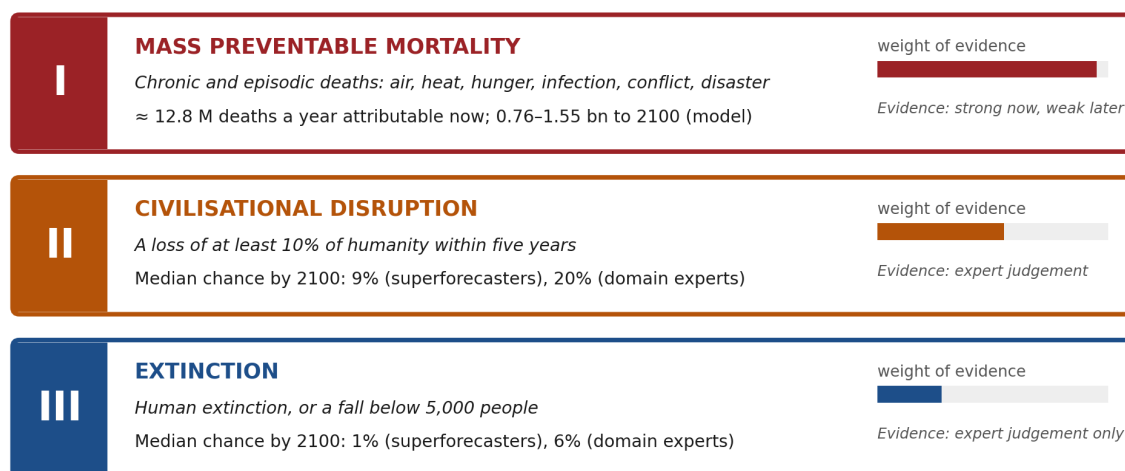


Figure 2. Three tiers of survival, with the weight of evidence for each. Tier I is measured and modelled in this report; Tiers II and III are summarised from expert elicitation.

Sources: H Heuristics model (Tier I); [Forecasting Research Institute, near-term XPT report](#) (Tiers II and III, median forecasts by 2100). Evidence grades C and D.

2.3 Why the tiers are not summed

It is tempting to place all three on one scale of expected deaths. This report does not, for three reasons. The tiers have different evidence, so an expected value would blend measured numbers with unmeasured probabilities. They have different policy logics, since Tier I responds to development, health and environmental policy while Tier III responds to arms control, biosecurity and technology governance. And they interact: a world that fails Tier I, with high hunger, weak states and fragile health systems, is also a more dangerous place to face a Tier II shock.

2.4 What the model is, and is not

The Survival Exposure–Vulnerability Model (Section 8) is an accounting model: it scales measured burdens with demographic, hazard and vulnerability indices and compares three stylised worlds. It does not simulate the climate, the economy or the health system, but every driver of its results can be inspected and challenged.

3. The Baseline: Who Dies Now, and Why

Any account of the future has to be anchored in the present. The measured burden is large, concentrated in a few chronic causes and falling in some of its parts. It is also, in 2026, under stress from sources that were absent three years ago.

3.1 A century of progress, and its limits

The starting point is good news. The latest Global Burden of Disease analysis counts [60.1 million deaths worldwide in 2023](#), including 4.67 million among children under five, with global life expectancy back above pre-pandemic levels at 76.3 years for women and 71.5 for men, more than twenty years above 1950 (IHME findings as reported by Health Policy Watch). The UN's [2024 population prospects](#) put global life expectancy at 73.3 years in 2024 and rising to 77.4 years by 2054. Child mortality has fallen by more than half since 2000.

The limits are as important as the progress. The UN inter-agency group estimates that [4.9 million children under five died in 2024](#), 2.3 million of them in the first month of life, and that the pace of decline has slowed by more than 60 per cent since 2015. Sub-Saharan Africa accounts for 58 per cent of those deaths and Southern Asia for 25 per cent. Life expectancy ranges from about 83 years in high-income regions to about 62 in sub-Saharan Africa. The century begins with a world in which survival is still sharply unequal.

3.2 The burden by pathway

Figure 3 and Table 2 set out the measured burdens that are most relevant to the polycrisis. Three features stand out. First, air pollution dominates. The Health Effects Institute attributes [7.9 million deaths in 2023](#) to air pollution (4.9 million to ambient fine particles, 2.8 million to household cooking smoke and 0.47 million to ozone), and 86 per cent of those deaths come from non-communicable disease, including a first estimate of 626,000 dementia deaths. A separate analysis attributes about 8.7 million deaths in 2018 to [fine particles from fossil-fuel combustion alone](#), which is why air quality is the point where climate mitigation and public health most clearly coincide.

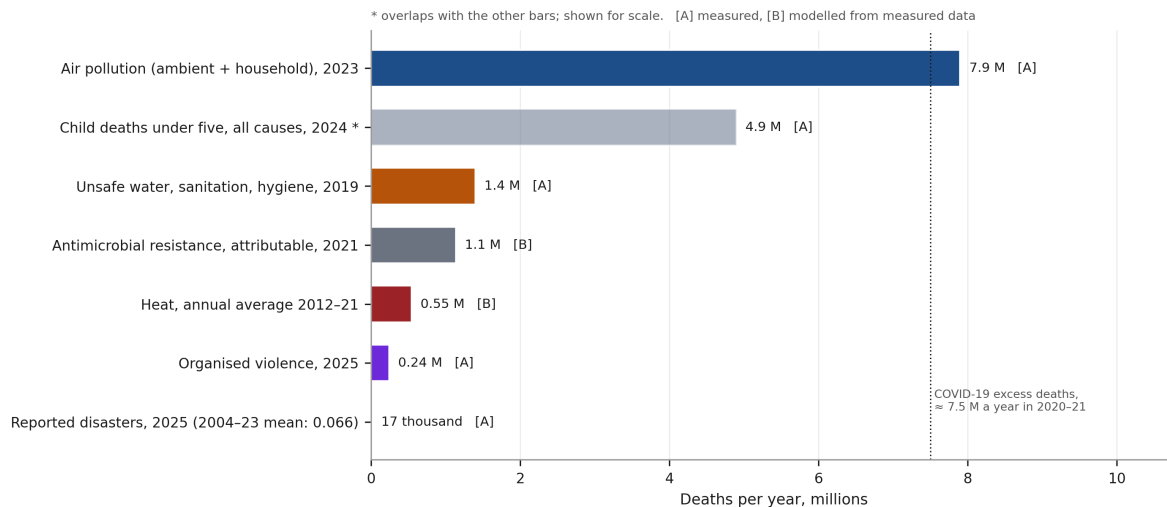


Figure 3. Measured annual deaths by pathway, most recent year available. The dotted line marks the annual rate of COVID-19 excess mortality in 2020 and 2021 for scale. Under-five deaths overlap the other bars.

Sources: [HEI State of Global Air 2025](#); [UN IGME](#); [WHO](#); [Oxford/GRAM](#); [Lancet Countdown 2025](#); [UCDP](#); [EM-DAT 2025](#); [WHO excess mortality](#). Grades A and B.

Second, the pathways that capture public attention are not the ones that kill the most people. Disasters recorded in EM-DAT killed [16,607 people in 2025](#), against a 2004 to 2023 annual average of about 65,600 that is dominated by a handful of mega-events. Organised violence killed about 245,000 people in 2025, a [record 65 state-based conflicts](#) and the highest level of one-sided violence since 1994, but that is still an order of magnitude below the toll from cooking smoke and ambient particles. Third, the climate-attributed items are real and rising: the 2025 [Lancet Countdown](#) puts heat-related deaths at an annual average of about 546,000 over 2012 to 2021, up about 63 per cent since the 1990s, and finds that 84 per cent of dangerous heatwave days in 2020 to 2024 would not have occurred without climate change.

Table 2. Measured annual mortality burdens most relevant to the polycrisis

Pathway	Annual deaths	Year	Grade	Source
Air pollution (ambient, household, ozone)	7.9 million	2023	A	HEI, State of Global Air 2025
Children under five, all causes	4.9 million	2024	A	UN IGME
Unsafe water, sanitation and hygiene	1.4 million	2019	A	WHO
Antimicrobial resistance (attributable)	1.14 million	2021	B	GRAM, via Oxford
Heat (average)	0.55 million	2012–21	B	Lancet Countdown 2025
Organised violence	0.245 million	2025	A	UCDP
Reported disasters	0.017 million	2025	A	EM-DAT
COVID-19 excess deaths (reference)	14.9 million over two years	2020–21	B	WHO

Pathways overlap: air-pollution deaths include deaths among children, and antimicrobial-resistance deaths are a subset of infection deaths. The rows cannot be summed.

3.3 Hunger, water and the unfinished basics

Hunger has fallen for three consecutive years but remains at a level that would have shocked the framers of the Millennium Development Goals. The [2026 State of Food Security and Nutrition](#) reports about 645 million people hungry in 2025, 7.8 per cent of the world and roughly 14 million fewer than a year earlier, with about 2.1 billion facing moderate or severe food insecurity and 2.7 billion unable to afford a healthy diet. Africa now holds the largest absolute number of hungry people, about 309 million. On water, the WHO and UNICEF's [2025 joint monitoring report](#) finds that 2.1 billion people still lack safely managed drinking water and 3.4 billion lack safely managed sanitation, including 354 million who practise open defecation. These deficits are the foundation of the infection and undernutrition channels in the model.

3.4 The treadmill beneath the progress

Two trends complicate the story of progress. The first is demographic: because the number of older people is growing quickly, counts of deaths from non-communicable causes rise even when risk per person falls. Counts of pollution deaths can rise without the air getting dirtier, simply because there are more older bodies breathing it. The second is institutional. Antimicrobial resistance already attributes [about 1.14 million deaths a year](#) and, absent further action, is forecast to attribute 1.91 million a year by 2050, with about 39 million cumulative deaths between 2025 and 2050. The 2020 to 2021 pandemic left [14.9 million excess deaths](#), and the legal architecture that was meant to prevent a repeat is incomplete: WHO member states [extended negotiations on the pathogen-sharing annex](#) in May 2026, and the 2025 Pandemic Agreement cannot take effect without it.

The supply of resources to push against these trends is shrinking at the moment it is most needed. [Displacement](#) stood at 117.8 million people at the end of 2025, a first decline in a decade but from a record level and largely through returns made in hard conditions. [Aid fell 23.1 per cent in real terms in 2025](#) to US\$174.3 billion, the largest drop on record, and the OECD expects further falls. The baseline for the century is therefore not simply "today's burden"; it is today's burden plus a weakening of the systems that have been reducing it.

4. Hazard Trajectories to 2100

Hazards are the part of the risk equation that attracts the most attention and the least agreement. The physical trajectories of warming and pollution are reasonably bounded to mid-century; beyond that they depend on choices not yet made. This section reviews the hazards that matter for survival and, where it can, says how sure the science is.

4.1 Warming: a narrowing but still wide range

The world has already warmed by about 1.4 to 1.5 degrees Celsius above the pre-industrial level. The WMO estimates that 2024 was about 1.55 degrees warmer (with an uncertainty of 0.13) and that the first eight months of 2025 averaged [about 1.42 degrees](#), with the eleven years from 2015 to 2025 the eleven warmest on record. The UNEP [Emissions Gap Report 2025](#) puts end-century warming at 2.3 to 2.5 degrees if every national pledge is fully implemented and 2.8 degrees on current policies, down from 2.6 to 2.8 and 3.1 in the previous edition. Part of that improvement is methodological, and UNEP warns that a temporary overshoot of 1.5 degrees is now very likely within the next decade. The [Climate Action Tracker](#) offers a similar spread, from about 1.9 degrees in its most optimistic scenario to 2.6 on current policies.

The model in Section 8 therefore uses three warming paths: about 1.9 degrees by 2100 in a mobilised world, about 2.45 in a muddling-through world and about 2.95 in a drifting world (Figure 4). The drifting path sits above UNEP's current-policy estimate to reflect the risk that policies slip, and the range is deliberately wide in the Monte Carlo analysis. The difference between the paths is about one degree. In epidemiological terms, as Section 9 shows, a degree is less decisive for global deaths than other choices; for particular places and groups, it is decisive.

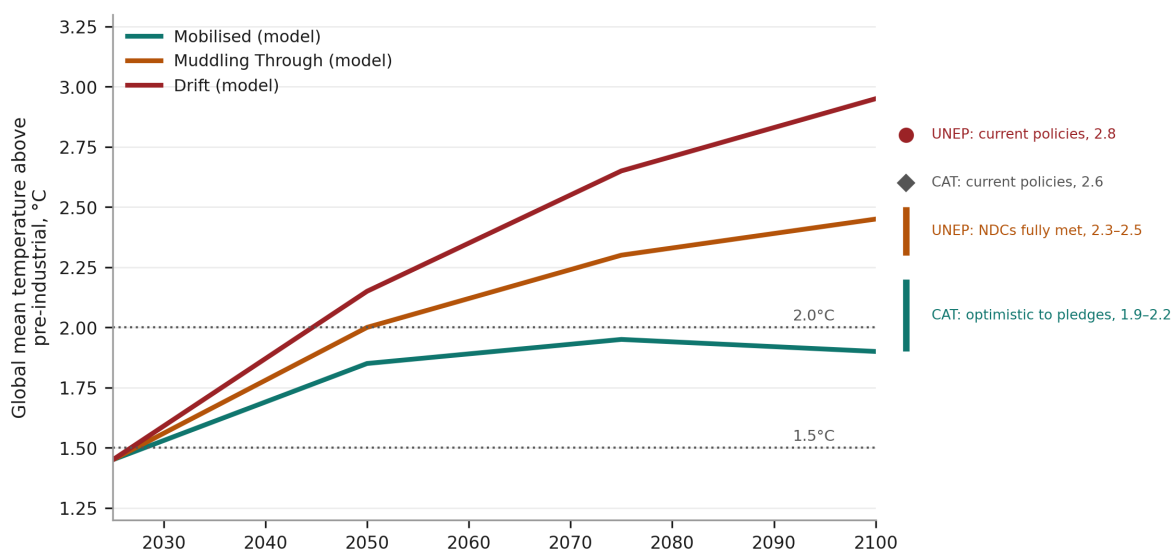


Figure 4. Warming paths used in the model, with published central estimates of end-century warming for comparison.

Sources: H Heuristics model paths; [UNEP Emissions Gap Report 2025](#); [Climate Action Tracker](#). Grade C (published estimates) and D (model paths).

4.2 Heat: the hazard that is moving fastest in human terms

Heat is the clearest mortality channel directly attributable to climate change. The 2025 Lancet Countdown reports that the average person in 2024 experienced [16 days of dangerous heat that would not have occurred without climate change](#), and people over 65 and infants about 20 heatwave days each, an increase of about 300 and 390 per cent respectively over the 1986 to 2005 baseline. In Europe, [ISGlobal estimates](#) about 62,775 heat-related deaths in summer 2024 and more than 181,000 across the summers of 2022 to 2024, with a plausible range for 2024 from 35,000 to 85,000.

The economic and demographic literature suggests the trend will continue. Bressler's [mortality cost of carbon](#) finds that emitting about 4,434 tonnes of carbon dioxide, the lifetime emissions of 3.5 average Americans, causes one additional death in expectation through temperature alone, and reports about 83 million cumulative excess temperature-related deaths between 2020 and 2100 on a business-as-usual path. [Carleton and co-authors](#) value net mortality risk, after adaptation costs and benefits, at about 3.2 per cent of global output in 2100 under high emissions, with losses concentrated in poor, hot places and gains in cold ones. The signal that matters for this report is not the exact figure but the pairing: temperature raises mortality, and income and adaptation flatten the response.

4.3 Dangerous heat and the human climate niche

A complementary view asks how many people will live outside the climatic conditions that have historically supported dense human settlement. [Lenton and colleagues](#) estimate that more than 600 million people, about 9 per cent of the population, are already outside that niche, and that about 60 million, under 1 per cent, face a mean annual temperature of 29 degrees or more. At 2.7 degrees of warming, roughly the current-policy outcome, about 2 billion people, 22 per cent of the projected end-century population, would be exposed to that level of heat, against about 5 per cent at 1.5 degrees. Each further tenth of a degree adds about 140 million people to the exposed group. India and Nigeria carry the largest exposed populations, at more than 600 million and 300 million respectively at 2.7 degrees ([ScienceDaily summary of the study](#)).

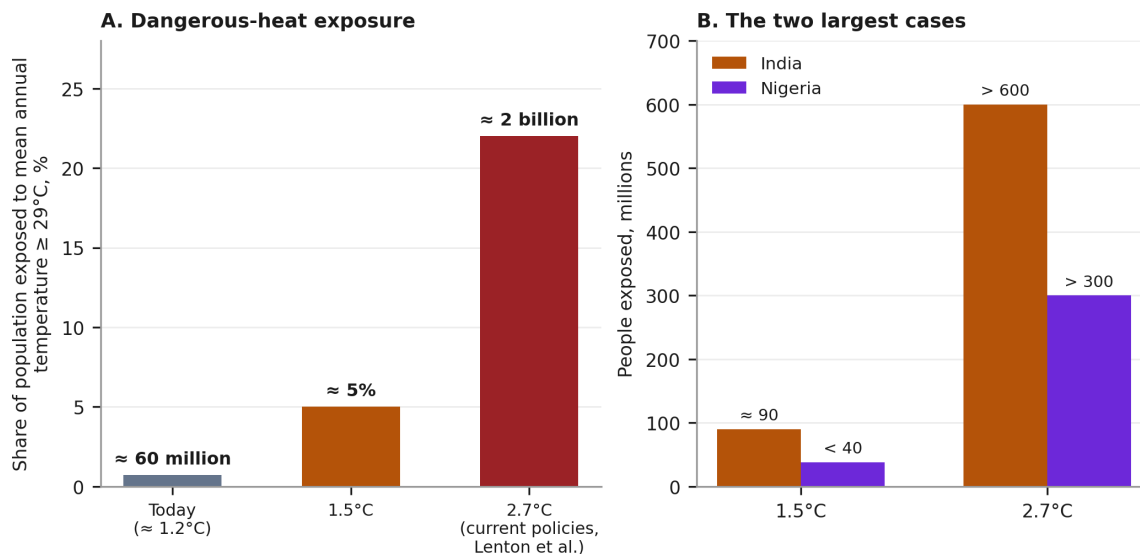


Figure 5. Exposure to a mean annual temperature of 29 degrees Celsius or more, today and at two warming levels, with the two most affected countries.

Source: [Lenton et al. \(2023\), Nature Sustainability](#), via the [authors' release](#). Population assumptions as published (about 9.5 billion for the country figures). Grade C.

4.4 Food, water and the earth system

Crop yields are a second pathway from hazard to death. A 2025 study in *Nature* by Hultgren and colleagues, using data from more than 12,000 regions, finds that each additional degree of global warming reduces staple-crop calories by about [120 kilocalories per person per day](#), about 4.4 per cent of recommended consumption, and that adaptation and income growth offset only about 23 per cent of losses by 2050 and 34 per cent by 2100 under a moderate-emissions scenario. Losses are largest in the modern breadbaskets, not only in poor regions, which makes this a shock to prices and trade as much as to local supply.

The wider earth system is moving in the same direction. The 2025 [Planetary Health Check](#) finds that seven of nine planetary boundaries are now breached, with ocean acidification added in 2025. The [Global Tipping Points Report 2025](#) concludes that warm-water coral reefs have already crossed their thermal tipping point and that the Atlantic overturning circulation and the Amazon are at risk at warming below 2 degrees. These are not modelled as mortality channels here, because the quantitative link to deaths is weak, but they raise the variance of food, water and storm outcomes in every scenario.

4.5 Sea level and storms

Sea-level rise is a slow hazard with fast consequences for exposure. [Kulp and Strauss](#), using corrected elevation data, found that about 110 million people already live on land below the current high-tide line and that about 300 million live on land projected to flood at least annually by 2050, regardless of how aggressively emissions are cut. The mortality from coastal flooding has historically been dominated by storm surges, and Section 6 shows how far warning systems and shelters can bend that curve.

4.6 Non-climate hazards that interact with climate

Three hazards are not climate hazards but interact with them. **Antimicrobial resistance** is a slow-moving pathogen hazard whose consequences depend on health-system strength and on antibiotic use in agriculture

and clinics. **Pandemics** are fat-tailed and episodic, as the COVID-19 experience of 14.9 million excess deaths in two years showed, and are made more likely by animal-human contact, mobility and weak surveillance. **Armed conflict** has risen sharply: the Uppsala Conflict Data Program records [65 state-based conflicts in 2025, a record](#), with interstate conflicts doubling for the second year running. A synthesis by [Mach and colleagues](#) of expert judgement found that climate has been a minor but real influence on organised armed conflict to date, and that its influence would grow with warming. Section 10 deals with the nuclear and technological hazards that matter for the tail.

4.7 A note on 2026: stress-testing the framework in real time

The framework is being tested as this report is finalised. In April 2026 the FAO warned that disruption of shipping through the Strait of Hormuz, with [tanker traffic down by more than 90 per cent](#), could transmit through four channels (imports, energy costs, farm margins and remittances) into a global food-price crisis within six to twelve months. Fertiliser prices had already risen sharply: the FAO reported urea up 52 per cent in the United States and 60 per cent in Brazil by mid-April. This report cannot say how the episode ends. It is included because it shows, in a single event, the coupling between an energy shock, agricultural inputs, prices and hunger that the polycrisis literature describes, and because the model's amplification term (Section 8) is intended to capture exactly that kind of cross-system transmission.

5. Exposure: A Larger, Older, More Urban World

Exposure is the least glamorous term in the risk equation and the most predictable. The people who will be alive in 2050 and 2075 are, for the most part, already born or can be projected with moderate confidence. Where they live, and how old they are, shapes who is in the path of every hazard.

5.1 Population: peak, plateau and an older world

The UN's 2024 revision of the World Population Prospects projects that the world's population, [about 8.2 billion in 2024](#), will peak at about 10.3 billion in the mid-2080s and decline slowly to about 10.2 billion by 2100, with an 80 per cent probability that the peak occurs between the mid-2060s and 2100. The 2100 projection is 6 per cent, or about 700 million people, smaller than a decade earlier. The more important result for survival is compositional. By 2080 the number of people aged 65 and over is projected to exceed the number of children under 18, and by the mid-2030s those aged 80 and over will outnumber infants.

Ageing has an immediate arithmetical consequence for any attributable-mortality estimate. Heat, air pollution and most infections kill older people at much higher rates than younger ones, so the same atmospheric exposure produces more deaths in an older world. In the model, the 65-plus population index rises from 1.0 in 2025 to about 1.75 in 2050 and about 2.6 in 2100 (assumptions informed by the UN projections, and varied in the sensitivity analysis). Population ageing alone adds about 490 million deaths to the drifting world's cumulative total.

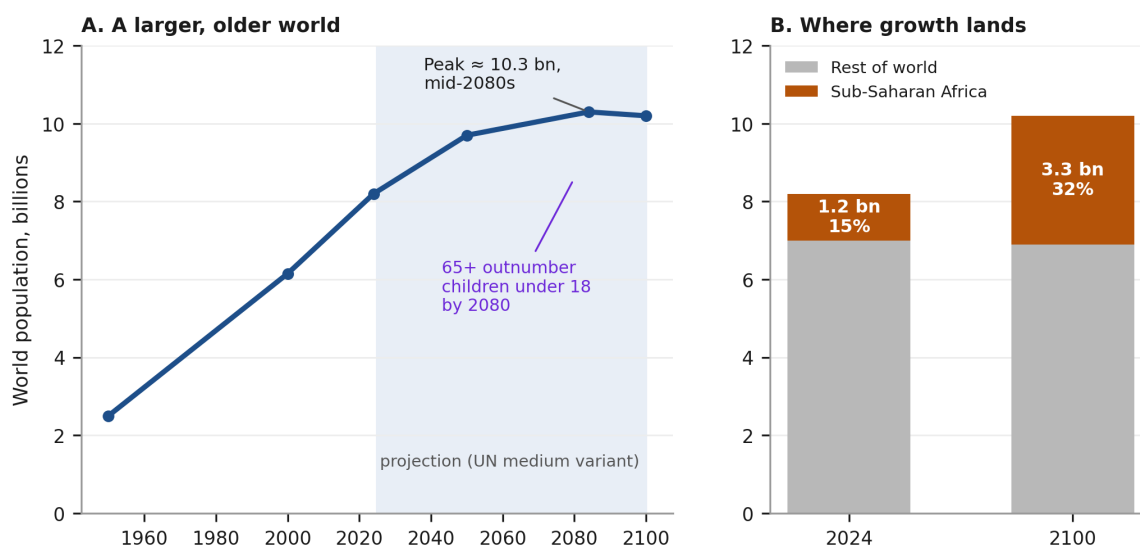


Figure 6. World population, 1950 to 2100 (UN medium variant, anchor points), and the share held by sub-Saharan Africa in 2024 and 2100.

Source: [UN World Population Prospects 2024](#); sub-Saharan Africa 2024 value derived from the UN's reported rise of 79 per cent to 2.2 billion by 2054. Line is interpolated between published anchor points. Grade C.

5.2 Where growth lands

Growth is concentrated where vulnerability is highest. Sub-Saharan Africa's population is projected to rise by 79 per cent to 2.2 billion by 2054 and to [about 3.3 billion by 2100](#), roughly one-third of humanity. It is the region with the largest absolute number of hungry people, the highest child mortality and, in the Lenton et al. results, some of the highest prospective exposure to dangerous heat. The aggregate survival outlook

for the century therefore depends disproportionately on whether health, food and cooling systems can be built in a handful of countries before the demographic wave arrives.

5.3 Cities, coasts and the geography of exposure

The built environment determines how much of a hazard turns into harm. Urban heat islands raise temperatures in the places where older and poorer residents often live in poorly ventilated housing; informal settlements concentrate people in floodplains and on hillsides; and coastal megacities concentrate exposure in the zones that [Kulp and Strauss](#) identify as vulnerable to annual flooding by mid-century. In the model, an exposure index for floodplains and coastal zones rises by about 25 per cent by 2050 and 45 per cent by 2100. That is an assumption, not a projection; it is large enough to matter for disasters and small enough not to dominate any total, because disasters account for a very small share of mortality in every scenario.

5.4 Displacement: exposure that moves

Exposure is not fixed; people move. The World Bank's [Groundswell report](#) estimated that as many as 216 million people could migrate within their own countries by 2050 because of slow-onset climate impacts, including 86 million in sub-Saharan Africa and 40 million in South Asia, though far fewer under rapid mitigation and inclusive development. [UNHCR counted 117.8 million forcibly displaced people](#) at the end of 2025, and the Internal Displacement Monitoring Centre's [Global Report on Internal Displacement 2026](#) records conflict and violence as the leading driver of new internal displacement. Displacement raises mortality indirectly, through lost income, interrupted care and exposure to disease and violence in transit, and its effect is captured in the model through the conflict-and-fragility channel and the amplification term.

6. Vulnerability: Where Harm Lands

The same heatwave, the same cyclone and the same price spike produce very different numbers of funerals in different places. The reason is vulnerability: the set of conditions, from income and health to housing and governance, that determines how much harm a given hazard does.

6.1 Vulnerability can fall fast

The most encouraging finding in the survival literature is that vulnerability is not destiny. The Bay of Bengal cyclone record is the clearest case. The 1970 Bhola cyclone killed, by various estimates, [between 300,000 and 500,000 people or more](#). Bangladesh had 44 cyclone shelters then; it now has about 5,500, a volunteer-based Cyclone Preparedness Programme of about 76,000 members and an operational warning system ([UNDRR](#)). When Cyclone Amphan struck in 2020, one of the most powerful storms ever recorded in the Bay of Bengal, [fewer than 30 people died in Bangladesh](#). Hazard intensity did not fall; vulnerability did.

Heat shows the same pattern at smaller scale. Ahmedabad introduced South Asia's first heat action plan after a 2010 heatwave, and a published evaluation estimated that the plan helped avoid about [1,100 to 1,190 deaths a year](#) relative to the pre-plan baseline (figures differ by source; the evaluation compares 2014–15 with 2007–10 without a control city, so the estimate is evidence of a signal, not a precise number). Nationally, early warning is associated with large differences in outcomes: the WMO reports that disaster mortality is [about six times higher in countries with limited early-warning coverage](#), and that 119 countries, about 60 per cent, now report multi-hazard systems, though only 43 per cent of small island developing states do.

6.2 The determinants of vulnerability

Five clusters of determinants recur across pathways. **Poverty** limits the ability to cool, to evacuate, to insure and to buy food at a spike; the World Bank's revised poverty line of US\$3 a day implies [about 808 million people in extreme poverty in 2025](#), mostly in sub-Saharan Africa. **Health-system capacity** governs whether illness becomes death; the gap of about 21 years in life expectancy between high-income regions and sub-Saharan Africa is partly a gap in primary care, vaccination and emergency services. **Food and water security** set the baseline for undernutrition and infection: 2.1 billion people lack safe drinking water and 2.1 billion experience moderate or severe food insecurity. **Age** is the most important individual factor for heat and pollution mortality, which is why Section 5's ageing result matters. **Governance and conflict** can overwhelm every other factor: in fragile contexts, safely managed drinking-water coverage is [38 percentage points lower](#) than elsewhere.

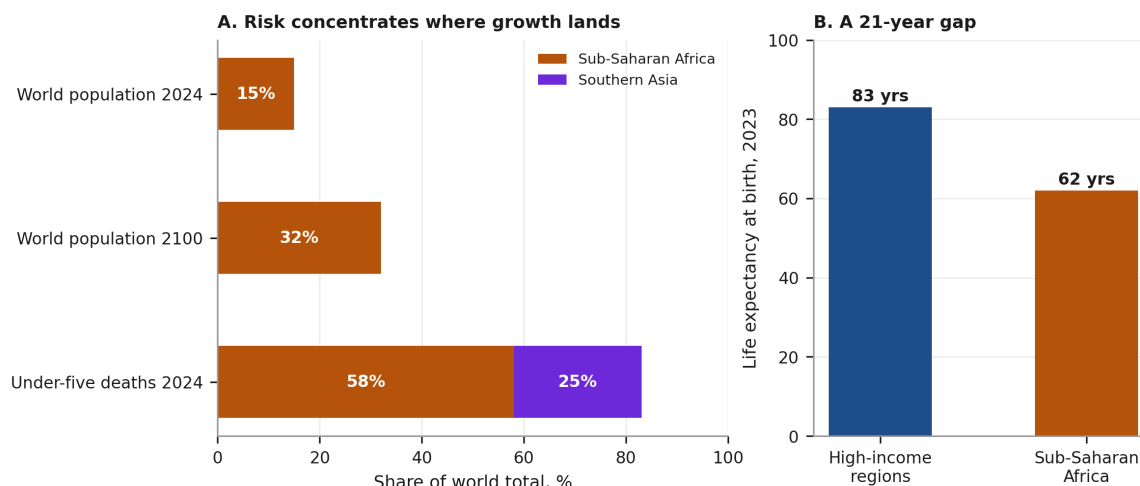


Figure 7. Vulnerability is geographically concentrated. Panel A shows shares of world population and of under-five deaths; panel B shows the life-expectancy gap.

Sources: [UN World Population Prospects 2024](#) (population shares; 2024 share derived); [UN IGME](#) (under-five deaths); [GBD 2023](#) (life expectancy, high-income regions versus sub-Saharan Africa). Grades A and C.

6.3 How vulnerability enters the model

The model represents vulnerability as a multiplier on the hazard that falls over time at a channel-specific rate. In a mobilised world, vulnerability to heat falls by about 1.4 per cent a year, to infection and undernutrition by about 2.2 per cent a year (roughly the pace of child-mortality decline since 2000), and to extreme events by about 2.5 per cent a year. In a drifting world, those rates fall to 0.4, 0.7 and 0.7 per cent a year. The difference between the two sets of rates is the central uncertain quantity in the analysis, and Section 9 shows how much depends on it. The rates are assumptions, calibrated to historical experience and varied by a factor of 0.5 to 1.5 in the sensitivity analysis.

Table 3. Vulnerability reduction in the three worlds: assumed annual rate of decline in the vulnerability multiplier

Pathway	Mobilised	Muddling Through	Drift	Historical anchor
Heat	1.4% a year	0.9% a year	0.4% a year	Heat plans and cooling access; Ahmedabad (Grade B)
Hunger and infection	2.2% a year	1.5% a year	0.7% a year	Under-five deaths fell by more than half since 2000; decline slowed since 2015 (Grade A)
Extreme events	2.5% a year	1.7% a year	0.7% a year	Bangladesh cyclone deaths; early-warning coverage (Grade B)
Air pollution (case fatality)	0.5% a year	0.35% a year	0.25% a year	Improvements in non-communicable disease care (Grade C)

Rates apply to the vulnerability multiplier; separate hazard paths govern pollution concentrations and conflict intensity. Parameters are given in Appendix A.

7. Pathways and Cascades

Sections 4 to 6 described the terms of the risk equation one at a time. In a polycrisis they are never independent. This section shows how hazards, exposure and vulnerability interact, and how a shock that starts in one system reaches people through another.

7.1 The mortality pathways

Six pathways carry most of the burden that this report can measure, and three more carry most of the tail (Figure 9). **Air pollution** operates through chronic cardiovascular, respiratory and neurological disease, and is driven by fossil-fuel combustion, solid-fuel cooking, dust and fire. **Heat** kills acutely, through heat stroke and cardiovascular events, and chronically, by stressing kidneys and by reducing working capacity. **Hunger and infection** link food insecurity, unsafe water, diarrhoeal disease, malaria and respiratory infection, and are sensitive to both climate and income. **Extreme events** (floods, storms, drought, wildfire) cause relatively few deaths in recent years but are the pathway most responsive to early warning. **Conflict and fragility** kill directly and indirectly, through hunger and the collapse of health services. **Antimicrobial resistance** raises the death rate from ordinary infections.

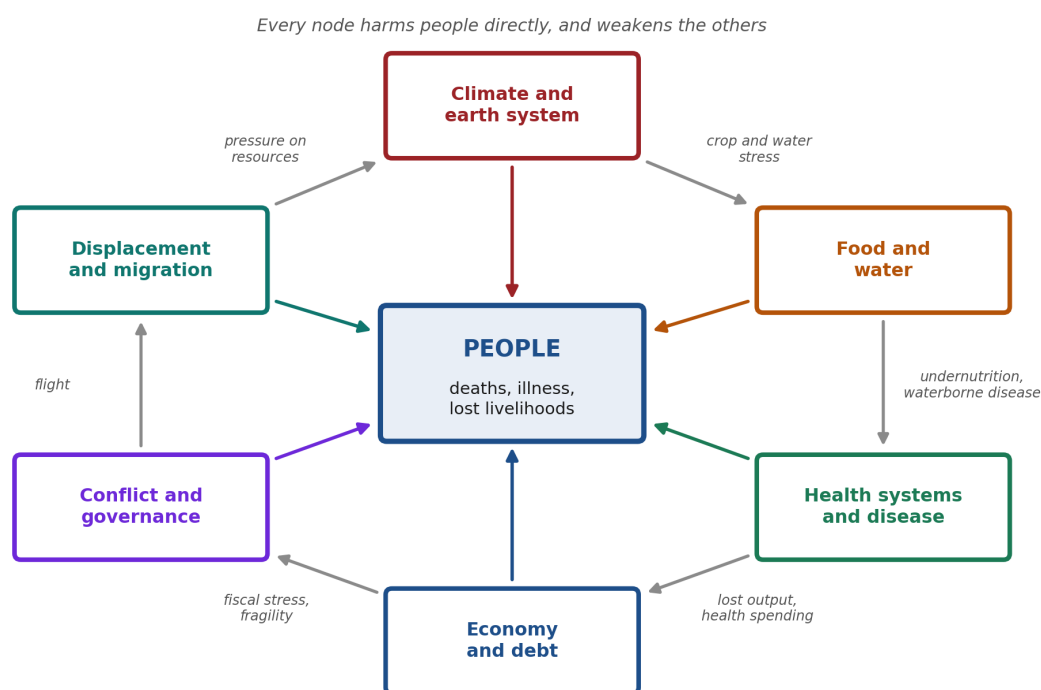


Figure 8. The polycrisis as a system of mutually reinforcing stresses. Each system harms people directly, and weakens the others.

Source: H Heuristics, drawing on [Lawrence et al. \(2024\)](#) and the [WEF Global Risks Report 2026](#). Conceptual schematic.

Pathway	Burden today	Direction to 2100	Evidence	Main lever
Air pollution	7.9 M a year	falls with clean air; ageing pushes counts up	●●●●	clean energy, cooking
Heat	0.55 M a year	rises with warming; falls with cooling, plans	●●●●	heat plans, cooling
Hunger and infection	≈ 2 M a year	falls with development; shocks reverse it	●●●○	food, water, primary care
Extreme events	0.02–0.07 M a year	hazard rises; early warning cuts deaths	●●●●	early warning, shelters
Conflict and fragility	0.25 M direct	contested; fragile states most at risk	●●○○	peace, state capacity
Antimicrobial resistance	1.1 M attributable	rises without stewardship	●●●○	stewardship, new drugs
Pandemics	≈ 7.5 M a year, 2020–21	episodic and fat-tailed	●●●○	surveillance, vaccines
Nuclear war	none since 1945	arms control weakening	●○○○	arms control, de-alerting
Advanced AI	not yet measurable	deeply uncertain	○○○○	safety research, rules

Evidence strength: ●●●● strong, measured · ●●●○ moderate · ●●○○ limited · ●○○○ weak, model-based · ○○○○ very weak

Figure 9. Mortality pathways: burden today, direction to 2100, strength of evidence and the main lever for each.

Source: H Heuristics assessment from the sources cited in Sections 3 to 4 and 10. Evidence dots are a qualitative judgement.

7.2 Four transmission mechanisms

The cascades that matter for survival run through four recurring mechanisms. The first is **price transmission**: a shock to energy or fertiliser raises food prices and cuts real incomes, with effects on hunger and, later, on political stability. The 2026 shipping disruption and the 2022 agricultural-price spike are both examples. The second is **fiscal transmission**: debt service crowds out health, social protection and disaster-preparedness spending, and a disaster raises the debt service burden for the next one. The third is **institutional transmission**: conflict, displacement or political polarisation disables the public-health and warning systems that reduce vulnerability. The fourth is **biological transmission**: a pandemic or a resistant pathogen exploits weakened health systems, and a pandemic in turn disrupts routine immunisation and care.

7.3 Compound events

Compound events, in which more than one hazard strikes at the same time or in sequence, are the strongest empirical signature of the polycrisis. The 2020 to 2021 pandemic coincided with the first large-scale reversal of global hunger and poverty reduction in a generation. In such cases the death toll is larger than the sum of what each hazard alone would have produced, because the capacity that would have contained one is already consumed by another. The model captures this with a single amplification term, which scales with warming and with the delivery strain of the scenario, applied to the hunger-and-infection, extreme-events and conflict channels. The term is a Grade D assumption and the largest source of uncertainty in the model's differences between worlds, a point taken up in Section 9.

7.4 The climate-conflict link

Whether climate causes conflict is among the most contested questions in the field. Mach and colleagues' [expert assessment](#) concluded that climate has been influential, but less than other drivers such as low socio-economic development and weak state capacity, and that the influence would rise with warming. The report's model treats climate as a multiplier on fragility rather than as a direct cause: conflict intensity follows scenario-specific paths, and the amplification term adds a climate-and-strain increment. If the link is stronger than assumed, the gap between the worlds would be larger.

8. The Survival Exposure–Vulnerability Model

The measured evidence in Sections 3 to 7 describes the present and the near future. To think about the century as a whole, the report needs a way to combine demography, hazard and vulnerability and to compare worlds. The Survival Exposure–Vulnerability Model is a deliberately simple accounting model built for that purpose.

8.1 Structure

For each of six pathways c and each year t from 2025 to 2100, attributable deaths in a world s are the product of five terms:

- **Baseline burden $B(c)$.** The measured or best-estimated annual deaths in 2025, from Section 3: air pollution 7.9 million; heat 0.60 million; hunger and infection 2.0 million (diarrhoeal disease, malaria and direct nutritional deaths, an order-of-magnitude figure); extreme events 0.065 million (the 2004 to 2023 mean); conflict 0.245 million directly, scaled by an indirect-to-direct ratio of about 1 to 5; antimicrobial resistance 1.25 million.
- **Exposure index $X(c, t)$.** A demographic index for each pathway: the population aged 65 and over for air pollution and heat, the under-five cohort for hunger and infection, total population for conflict, and a floodplain and coastal index for extreme events.
- **Hazard multiplier $H(c, s, t)$.** For heat, hunger and extreme events, a function of warming above today's level with uncertain sensitivities; for air pollution, a scenario-specific reduction in exposure (by 12, 35 or 65 per cent) as clean energy and clean cooking spread; for conflict, a scenario-specific intensity path.
- **Vulnerability multiplier $V(c, s, t)$.** An exponential decline at a channel- and scenario-specific rate (Table 3), representing health, adaptation, warning and social protection.
- **Polycrisis amplification $\phi(s, t)$.** A factor of at least 1 on the hunger, extreme-events and conflict channels, equal to 1 plus a scenario-specific strength times a stress index that grows with warming. It represents the coupling described in Section 7 and is a Grade D assumption.

Antimicrobial resistance is handled separately: it follows the published reference forecast of about 1.91 million attributable deaths in 2050, scaled by a scenario-specific factor of 0.6, 1.0 or 1.3 and extended to 2100 at scenario-specific growth rates. Uncertainty is carried by 20,000 Monte Carlo draws over the parameters in Appendix A. The same draws are used for all three worlds, so differences between worlds are paired and their uncertainty is smaller than the uncertainty in the levels.

8.2 The three worlds

The worlds are stylised combinations of choices, not predictions, and none corresponds to a single country's policy. **Mobilised** is a world in which emissions fall fast enough to hold warming near 1.9 degrees by 2100, clean cooking and clean power spread widely, health systems and early warning are extended to the most exposed, arms control and pandemic rules are restored and aid stabilises. **Muddling Through** corresponds to current pledges being broadly met, with warming near 2.45 degrees, and to development progress at about the pace of the last two decades. **Drift** is a world in which pledges slip, warming approaches 3 degrees, progress on health and development stalls, conflict rises and the polycrisis feeds on itself.

Table 4. Definitions of the three worlds

Assumption	Mobilised	Muddling Through	Drift
Warming above pre-industrial, 2100	≈ 1.9 °C	≈ 2.45 °C	≈ 2.95 °C
Cut in air-pollution exposure (eventual)	65%	35%	12%
Conflict intensity, 2100 (2025 = 1.0)	0.7	1.1	1.6
Vulnerability decline: heat (per year)	1.4%	0.9%	0.4%
Vulnerability decline: hunger and infection	2.2%	1.5%	0.7%
Antimicrobial-resistance deaths 2050 (reference = 1.0)	0.6	1.0	1.3
Polycrisis amplification strength	0.10	0.25	0.50

Reference points: warming paths follow the ranges in UNEP (2025) and the Climate Action Tracker; the reference antimicrobial-resistance forecast is the GRAM study cited in Section 3. All other values are H Heuristics assumptions (Grade D), varied in the sensitivity analysis.

8.3 What the model can and cannot say

The model can say how the burden of the six pathways would evolve under stated assumptions, how much of the difference between worlds comes from hazard, vulnerability and demography, which assumptions matter most, and what delay costs. It cannot say what the actual number of deaths will be, because pathways overlap and because the true uncertainty about parameters is larger than the ranges used. It cannot represent tipping points, abrupt regime changes or tail events, which are handled separately in Section 10. It does not model the economy, so it cannot say anything about costs, and it uses attributable rather than excess deaths, so it counts the whole burden of a risk factor and not only the increment due to climate change.

The last point deserves emphasis. The model's "deaths averted" are differences between worlds, not differences relative to a counterfactual without climate change. Air-pollution deaths in the model are mostly driven by emissions of fine particles and household smoke, which are only partly linked to the climate problem; they are included because the actions that cut greenhouse-gas emissions also cut them, and because ignoring them would understate the most immediate survival benefit of mitigation. The estimates for heat can be compared with the literature: Bressler's business-as-usual figure is about 83 million temperature-related deaths to 2100, against 79 million (67 to 92) for the muddling-through world and 114 million (98 to 134) for the drifting world here.

9. Results: Mortality Under Three Worlds

Three trajectories diverge from a common starting point of about 12.8 million attributable deaths a year. One falls to about 7 million by 2100, one stays near 15 million and one more than doubles to about 24 million. Cumulatively, the gap between the best and worst worlds is nearly 800 million lives.

9.1 Annual deaths

Figures 10 and 11 show the annual burden. In the mobilised world it peaks at about 13 million a year in the early 2030s and then falls steadily, reaching about 11 million in 2050 (10th to 90th percentile: 10 to 12) and about 7 million in 2100 (5 to 9). In the muddling-through world it rises to a plateau of about 15 million from 2050 and stays there, because falling risk per person is offset by ageing. In the drifting world it rises throughout, to about 19 million in 2050 (18 to 20) and about 24 million in 2100 (22 to 27). Air pollution is the largest component in every world: about 4.4 million deaths in 2100 under mobilisation, 9.2 million under muddling through and 13.4 million under drift. In the drifting world the other components together reach about 11 million, led by antimicrobial resistance (3.4 million), conflict and fragility (3.0 million), hunger and infection (2.1 million) and heat (2.1 million).

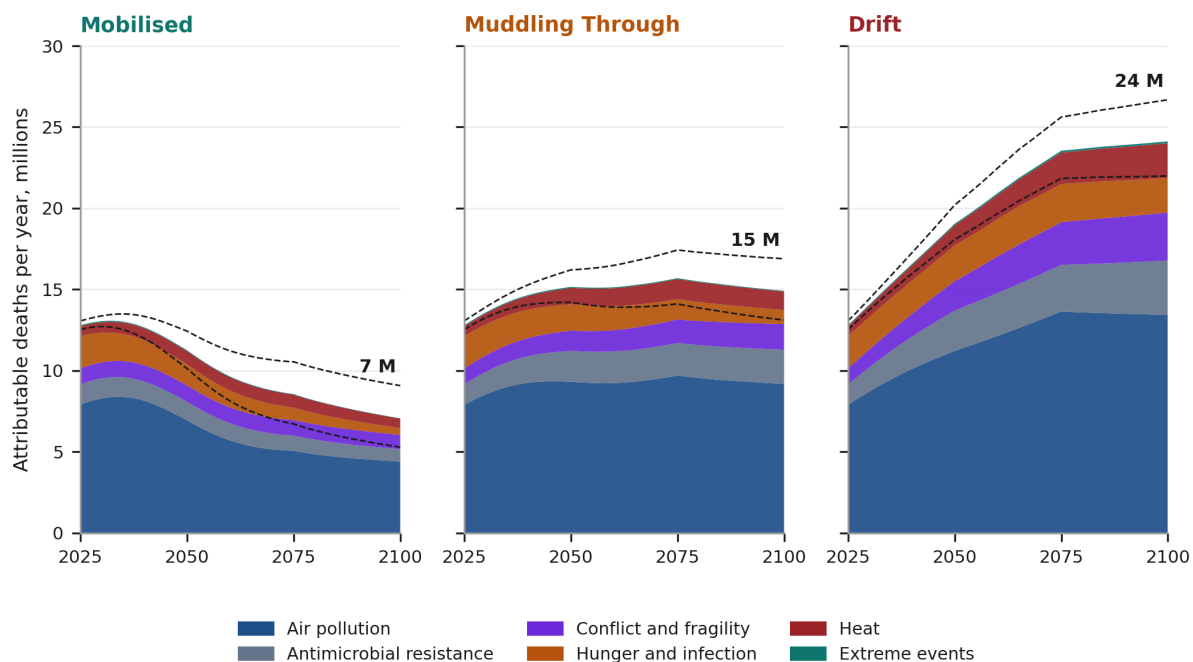


Figure 10. Annual attributable deaths by pathway (median), 2025 to 2100, in the three worlds. Dashed lines show the 10th and 90th percentiles of the total.

Source: H Heuristics, Survival Exposure–Vulnerability Model (20,000 draws). Grade D. Pathways overlap, so totals are accounting aggregates.

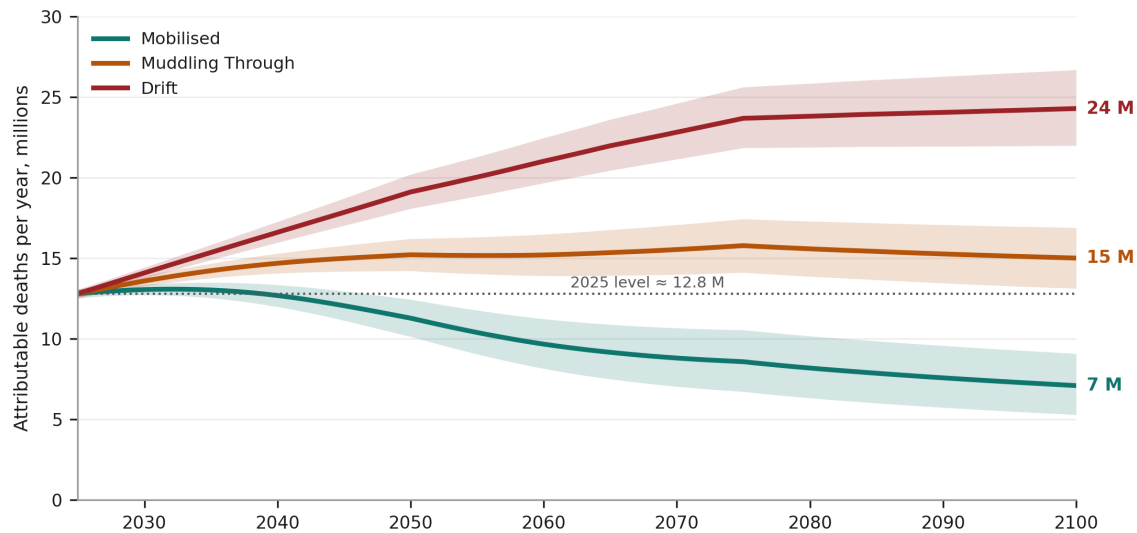


Figure 11. Total annual attributable deaths with 10th to 90th percentile bands, three worlds. The dotted line marks the 2025 level of about 12.8 million.

Source: H Heuristics, Survival Exposure–Vulnerability Model. Grade D.

9.2 Cumulative deaths and deaths averted

Over 76 years the cumulative attributable toll is about 757 million (658 to 862 million) in the mobilised world, 1.14 billion (1.05 to 1.23 billion) in the muddling-through world and 1.55 billion (1.45 to 1.66 billion) in the drifting world (Figure 12, Table 5). For reference, holding the 2025 rate constant for 76 years would produce about 970 million. The mobilised world therefore saves about 380 million lives relative to muddling through (337 to 422 million) and about 790 million relative to drift (706 to 888 million), and muddling through itself saves about 415 million relative to drift. These are not small numbers by any standard. They are, however, spread over three-quarters of a century and over a world population of about 9 to 10 billion that will itself experience several billion deaths from all causes.

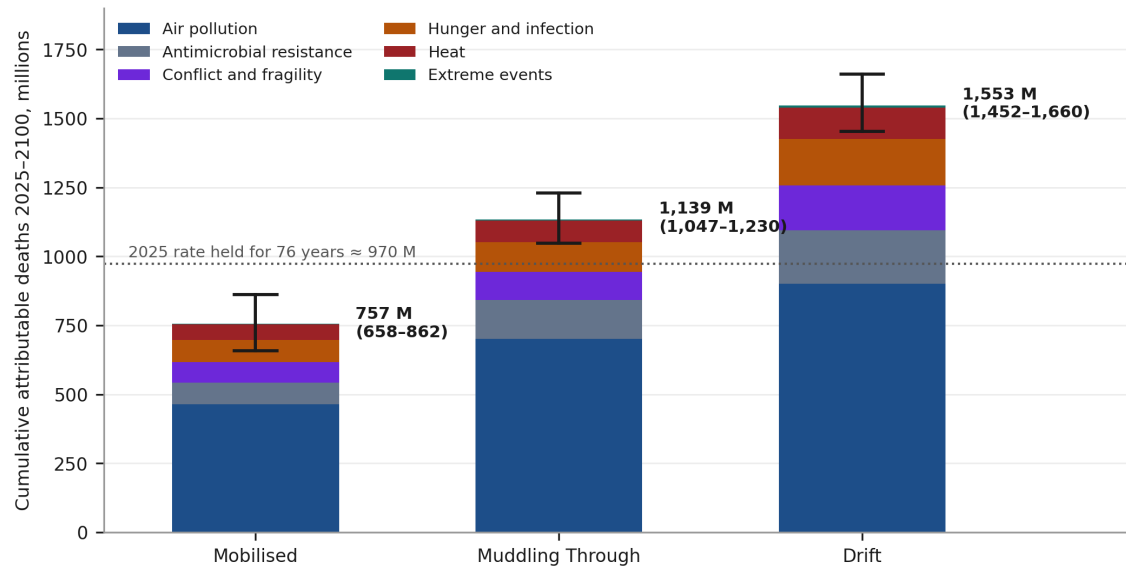


Figure 12. Cumulative attributable deaths, 2025 to 2100, by pathway (median) with 10th to 90th percentile ranges for the total.

Source: H Heuristics, Survival Exposure–Vulnerability Model. Grade D.

Table 5. Summary of results: attributable deaths, three worlds (millions; median with 10th to 90th percentile in brackets)

Measure	Mobilised	Muddling Through	Drift
Deaths per year, 2050	11 (10–12)	15 (14–16)	19 (18–20)
Deaths per year, 2100	7 (5–9)	15 (13–17)	24 (22–27)
Cumulative deaths 2025–2100	757 (658–862)	1,139 (1,047–1,230)	1,553 (1,452–1,660)
of which: air pollution	464	701	901
of which: antimicrobial resistance	78	142	194
of which: hunger and infection	81	109	167
of which: conflict and fragility	73	100	163
of which: heat	56	79	114
of which: extreme events	3	4	8
Deaths averted versus Drift	794 (706–888)	415 (366–470)	—
Deaths averted versus Muddling Through	378 (337–422)	—	—

Source: H Heuristics, Survival Exposure–Vulnerability Model (Grade D). Pathway medians do not sum exactly to totals because medians are not additive. Ranges reflect parameter uncertainty only.

9.3 Where the avoided deaths come from

Air pollution accounts for more than half of the avoided deaths. Of the 794 million lives separating the mobilised and drifting worlds, about 434 million (368 to 504 million) are air-pollution deaths, followed by antimicrobial resistance (116 million), conflict and fragility (89 million), hunger and infection (86 million), heat (58 million) and extreme events (5 million). Figure 13 shows both comparisons. The extreme-events

figure is small because disasters are a small share of mortality in every world; it should not be read as a reason to neglect early warning, which is cheap and effective and whose benefits are measured in livelihoods and assets as well as lives.

The dominance of air pollution is both a strength and a vulnerability of the result. It is a strength because the burden is measured, the causal chain is strongly established and the interventions, clean cooking and clean power, are well understood. It is a vulnerability because the size of the avoided burden depends on how much of the baseline is realistically preventable, which the sensitivity analysis tests. If clean-air gains in the mobilised world were 30 per cent smaller than assumed, deaths averted against drift would fall from about 794 million to about 691 million.

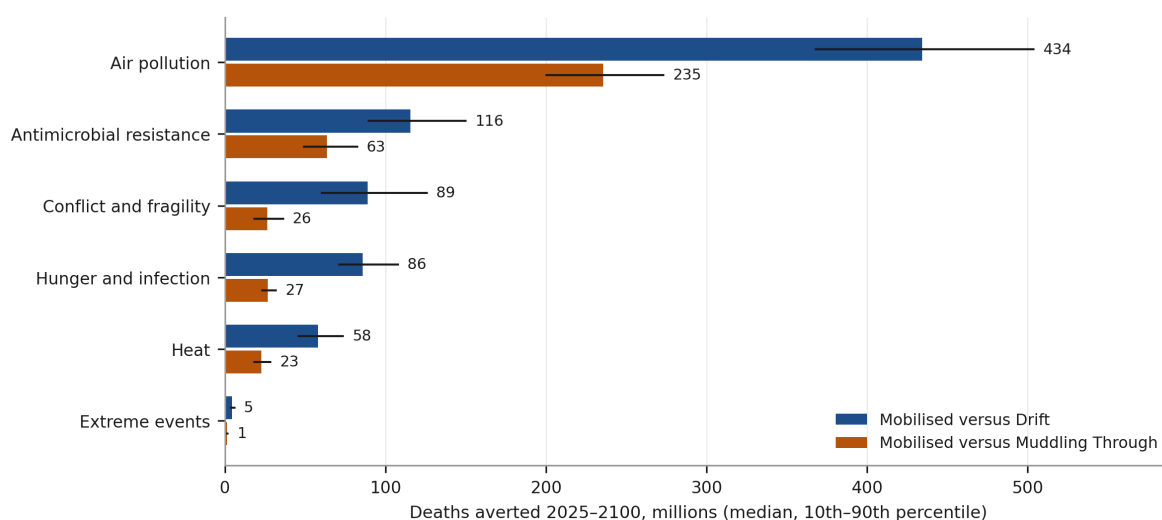


Figure 13. Deaths averted in the mobilised world, 2025 to 2100, by pathway, relative to drift and to muddling through.

Source: H Heuristics, Survival Exposure–Vulnerability Model. Grade D. Bars show medians; lines show 10th to 90th percentile ranges.

9.4 Hazard, vulnerability and demography

The model allows the sources of the gap to be separated (Figure 14). Starting from the drifting world, improving only the hazard side (warming, air quality and conflict intensity) lowers cumulative deaths from about 1,553 million to about 1,012 million, a saving of about 540 million. Improving only the vulnerability side (health care, heat adaptation, early warning, social protection) lowers it to about 1,194 million, a saving of about 360 million. Doing both lowers it to about 757 million, a saving of about 800 million. The savings overlap because a smaller hazard leaves less for vulnerability reduction to act on, and the total is about 100 million smaller than the sum of the parts.

A second decomposition asks what drives the drifting world's total. Ageing and population growth add about 486 million deaths relative to a world with the 2025 demographic structure; the growth in hazards (warming and conflict, with little change in air quality) adds about 84 million; and the vulnerability decline that occurs even in drift subtracts about 180 million. The most important driver of the future burden of attributable mortality is therefore not warming but demography. That is not an argument against mitigation, since demography is not a policy variable on a decade's horizon while hazards and vulnerability are. It is an argument for being honest that the main reason deaths rise in the muddling-through and drifting worlds is that an older population is more susceptible, and that the correct response is to lower the hazard and vulnerability at every age.

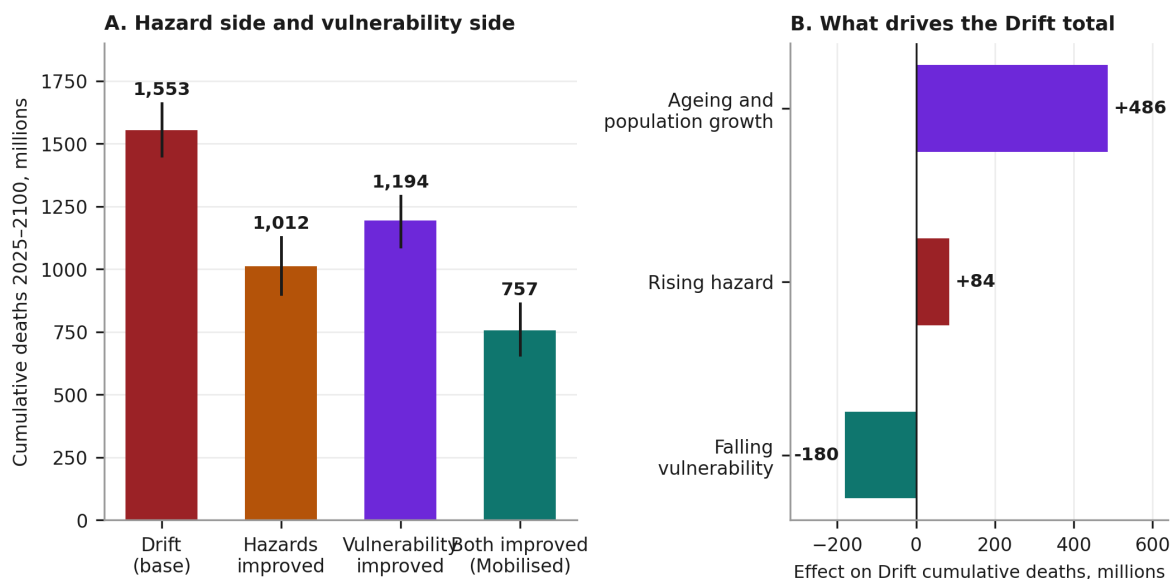


Figure 14. Panel A: cumulative deaths when the hazard side, the vulnerability side or both are moved from drift to mobilised settings. Panel B: effect of each driver on the drifting world's cumulative total.

Source: H Heuristics, Survival Exposure–Vulnerability Model. Grade D.

9.5 The cost of delay

Delay is the most policy-relevant result. If the mobilised pathway starts ten years late, so that vulnerability reduction and air-quality gains follow drift for the first decade and warming is about 0.2 degrees higher at the end of the century (using the IPCC's central estimate of about 0.45 degrees per 1,000 gigatonnes of cumulative carbon dioxide and about 40 gigatonnes a year of current emissions, see [IPCC AR6 Working Group I](#)), the cumulative toll rises by about 141 million deaths (107 to 169 million), or about 14 million for each year of delay (Figure 15). A five-year delay costs about 90 million and a twenty-year delay about 254 million. The costs rise more than proportionally because early investments in health, warning and clean air compound: they lower the baseline from which later reductions start.

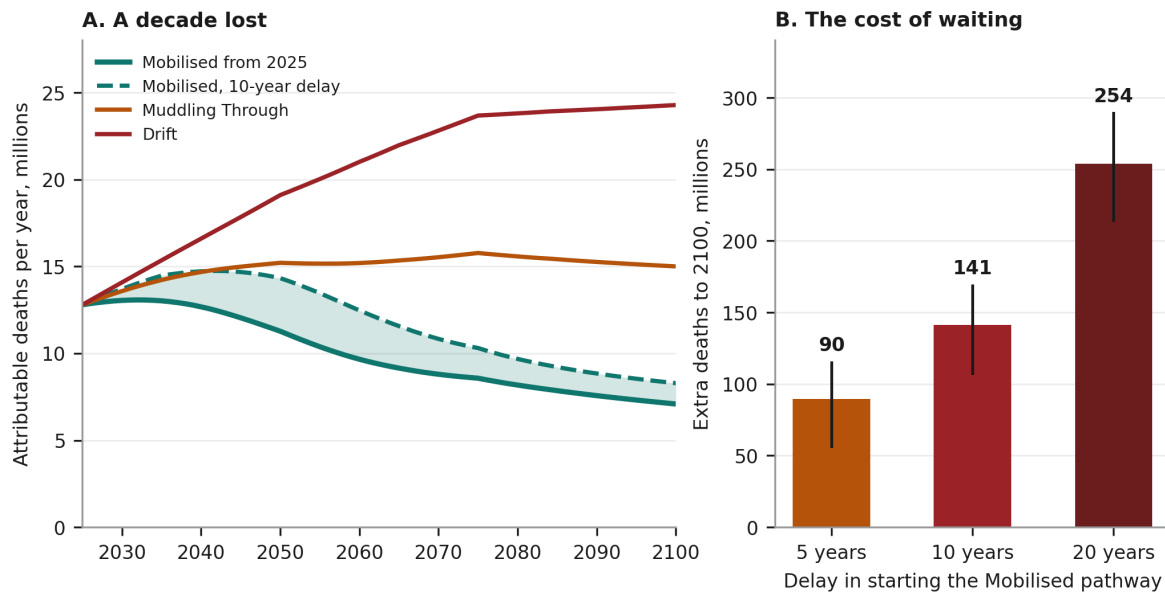


Figure 15. Cost of delay. Panel A: annual deaths when the mobilised pathway starts ten years late. Panel B: extra cumulative deaths to 2100 for delays of 5, 10 and 20 years.

Source: H Heuristics, Survival Exposure–Vulnerability Model. Grade D.

9.6 Sensitivity and robustness

Figure 16 shows how the central estimate of 794 million deaths averted changes when single assumptions are varied across plausible ranges. The result is most sensitive to the size of the air-pollution cut achieved (691 to 894 million) and to the strength of the polycrisis amplification (743 to 893 million). It is moderately sensitive to the gap between worlds in vulnerability reduction, the conflict indirect-to-direct ratio, the warming difference, the antimicrobial-resistance path and the growth of the older population, each of which moves the estimate by about 40 to 90 million. It is least sensitive to the heat parameters (782 to 808 million), which is a reminder that heat is a smaller part of the aggregate than its prominence in public debate suggests, even though it is the most climate-specific channel.

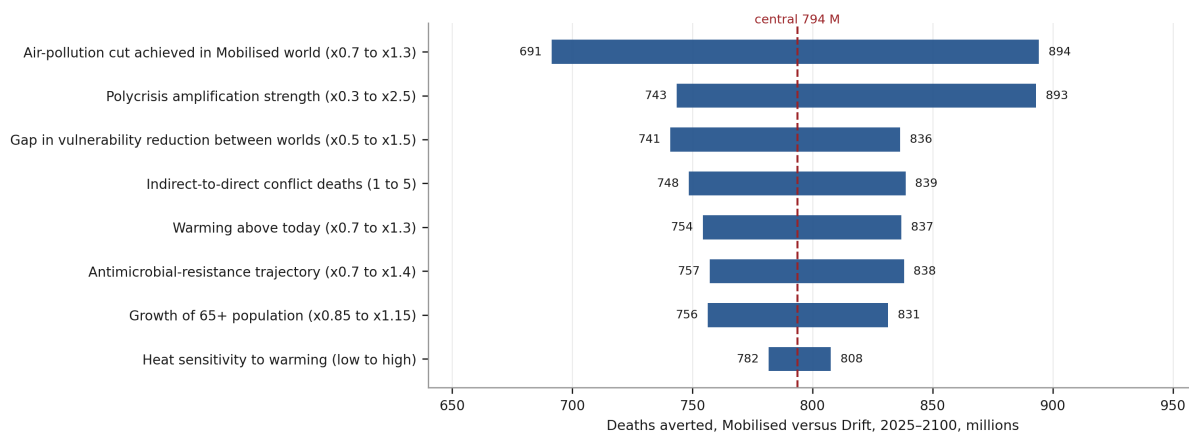


Figure 16. Sensitivity of deaths averted (mobilised versus drift, 2025 to 2100) to single assumptions.

Source: H Heuristics, Survival Exposure–Vulnerability Model. Grade D. Each bar varies one parameter across the range shown, holding others at their sampled values.

The qualitative conclusions are robust to every variation tested: the mobilised world is always best and the drifting world always worst; air pollution is always the largest contributor; the sign of the gap never changes. The numerical conclusions are not robust in the sense that an alternative set of defensible assumptions could produce a gap of 500 million or 1.2 billion. A reader who wants a single sentence should take this one: *the preventable mortality burden of the century is of the order of hundreds of millions of lives, most of it chronic, and most of it avoidable by choices that are available today.*

9.7 Comparison with the literature

The model's atmospheric burden can be checked against two published benchmarks. A 2024 study in *Nature Communications* by [Pozzer and colleagues](#) combines climate, chemistry and demographic projections to estimate that deaths attributable to fine particles and non-optimal temperature, both hot and cold, reach about 30 million a year by the end of the century (95 per cent interval 12 to 53 million) in a realistic middle scenario, from about 5.7 million in 2000. The model here gives about 10 million a year for air pollution and heat combined in the muddling-through world and 16 million in the drifting world in 2100, which is lower than their central value but inside their interval. A likely reason is that this model allows mortality rates from non-communicable disease to keep falling as health systems improve; the comparison cannot be exact because the studies differ in scope, scenarios and baseline mortality assumptions. The comparison is therefore a reminder that the largest uncertainty in the long-run mortality estimate is the pace at which health care improves, which is a policy choice as much as a scientific one.

The second benchmark is the World Health Organization's estimate that climate change would cause about [250,000 additional deaths a year between 2030 and 2050](#) through undernutrition (95,000), malaria (60,000), diarrhoea (48,000) and heat stress in older people (38,000). That estimate covers a narrower set of pathways and counts only the increment due to climate change, so it is not directly comparable with the attributable totals here. It does suggest that the climate-specific increment in the first half of the century is a small share of the attributable burden, and that the case for mitigation in the near term rests as much on air quality and on avoiding worse outcomes later as on mortality that climate change itself causes by 2050.

10. The Catastrophic Tail

Everything above concerns outcomes that can be measured or modelled with some discipline. The remaining question, whether the century could end in a catastrophe that kills a tenth or more of humanity, or in extinction, cannot be answered with the same tools. What can be done is to lay out what experts believe, what the scenario models show and what has changed recently.

10.1 What the forecasters think

The most systematic effort to elicit probabilities is the [Existential Risk Persuasion Tournament](#), run in 2022 by the Forecasting Research Institute with domain experts and superforecasters (published in the [International Journal of Forecasting](#)). Its median forecasts by 2100 were a 20 per cent chance of a global catastrophe, defined as a loss of at least 10 per cent of the population, and a 6 per cent chance of human extinction among domain experts; the superforecasters' medians were 9 per cent and 1 per cent ([Forecasting Research Institute, 2025](#)). The two groups differed most on artificial intelligence, where the median extinction estimates were about 3 per cent for experts and 0.38 per cent for superforecasters, and less on nuclear war. The philosopher Toby Ord's earlier estimates, in [The Precipice](#), put the probability of an existential catastrophe this century at about one in six, with unaligned artificial intelligence about one in ten, engineered pandemics about one in thirty, nuclear war about one in a thousand, climate change about one in a thousand, and all natural risks about one in ten thousand.

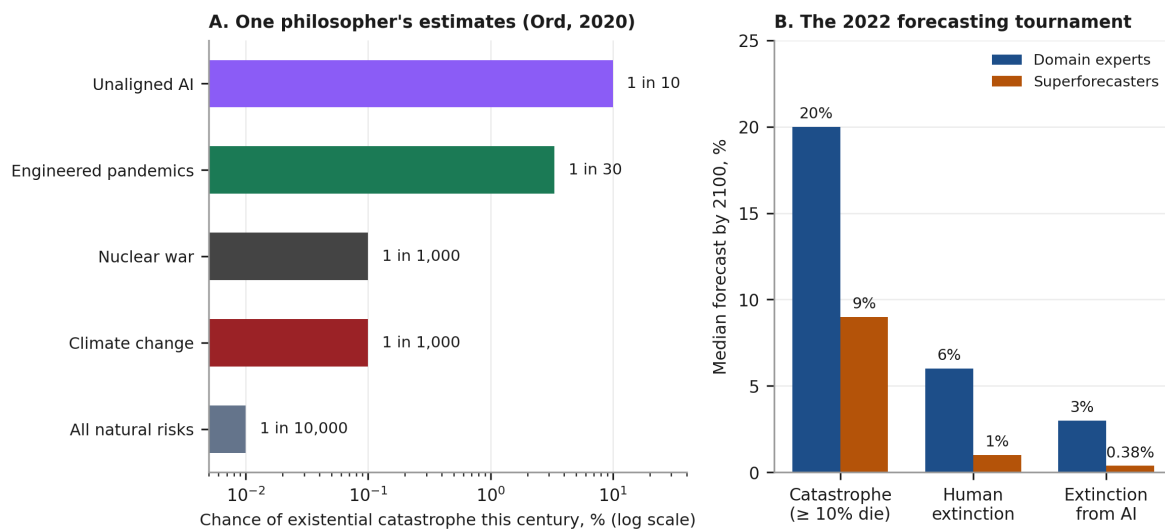


Figure 17. Two views of tail risk. Panel A: one philosopher's estimates of the chance of existential catastrophe by cause (log scale). Panel B: median forecasts by 2100 from the 2022 forecasting tournament.

Sources: Ord, [The Precipice](#) (2020; the natural-risk figure is Ord's combined estimate); [Forecasting Research Institute](#). Panel B's AI figures are from the tournament's published results as reported in [press coverage](#). Grade C.

Three cautions apply. The numbers are judgements, not frequencies, and the tournament authors themselves note that the field has no good way to check forecasts of very low-probability events. The groups did not converge despite structured debate, which suggests that more information, not more argument, is needed. And the estimates of different authors use different definitions, so they should not be added together. They are most useful as a guide to rank order: pathogens and advanced technology are viewed as larger sources of tail risk than climate change or natural hazards.

10.2 Nuclear weapons

Nuclear war is the one tail hazard for which there is a physical model of mortality, and the model is alarming. In a 2022 study in *Nature Food*, [Xia and colleagues](#) simulated the climate effects of soot from burning cities and found that a large war between the United States and Russia could reduce global caloric production by about 90 per cent three to four years after the exchange, and that more than 5 billion people could die of hunger; even a smaller India–Pakistan war, producing less soot, could cause more than 2 billion deaths ([press summary](#)). The study is a modelling exercise with strong assumptions about fire behaviour and the response of agriculture, and it is contested in the literature, but it sets the order of magnitude: nuclear war would be larger than every other cause considered here.

The institutional trend is adverse. SIPRI's 2026 Yearbook puts the global inventory at [about 12,187 warheads in January 2026, of which about 9,745 are in military stockpiles](#) and between 2,100 and 2,200 on high alert, and reports that the pace of dismantlement is slowing while several states modernise. The New START treaty, the last binding limit on US and Russian strategic forces, [lapsed in February 2026 with no successor](#). The immediate effect on mortality is nil; the effect on the probability of the tail is unknowable, but the direction is not in doubt.

10.3 Pandemics and engineered pathogens

COVID-19 left about [14.9 million excess deaths](#) in two years, from a pathogen that was not close to the worst imaginable in fatality. The tail risk lies in pathogens with higher lethality or transmissibility, whether natural or engineered, and in the declining cost of synthetic biology. The governance picture is mixed: the WHO Pandemic Agreement was adopted in 2025 but cannot take effect until the pathogen-access and benefit-sharing annex is agreed, and member states [extended those negotiations](#) after a session ending 1 May 2026 failed to conclude. Antimicrobial resistance, discussed in Section 3, is the slower cousin of the same problem.

10.4 Advanced artificial intelligence

The probability that advanced AI contributes to a catastrophe is the least measurable of any in this report. A 2023 survey of 2,778 AI researchers, published as [Thousands of AI Authors on the Future of AI](#), found that between 38 and 51 per cent of respondents, depending on how the question was framed, gave at least a 10 per cent chance to advanced AI leading to outcomes as bad as human extinction, alongside wide disagreement about timelines. The [International AI Safety Report 2026](#), led by Yoshua Bengio, assesses the risks from general-purpose AI and the effectiveness of mitigations, drawing on more than 100 experts and published in February 2026. This report takes no position on the probability. It notes that AI could also affect the tiers in the other direction, by improving forecasting, health care and energy systems, and that the sign of its net effect on survival is itself uncertain.

10.5 Climate change as a tail risk

The role of climate change in the tail is contested. Kemp and colleagues' [Climate Endgame](#) argues that catastrophic climate scenarios are dangerously underexplored, and proposes a research agenda built on four mechanisms (famine and malnutrition, extreme weather, conflict and vector-borne disease) and their interaction with financial and political crises. Critics argue that emphasising implausible scenarios crowds out attention to more plausible ones. Lenton and colleagues' finding that at 3.6 to 4.4 degrees of warming

half of the world's population could fall outside the human climate niche ([ScienceDaily summary](#)) is a reminder of what is at stake in the upper tail of the warming distribution. Ord assigns climate change a probability of about one in a thousand of causing existential catastrophe, noting that it is more likely to cause non-existential catastrophes that leave humanity more vulnerable to other risks. The consistent finding is that climate change is a threat multiplier for the tail rather than its most likely cause.

Table 6. Tail hazards compared

Hazard	Scale of consequence	Evidence	Recent development
Nuclear war	Hundreds of millions to billions through famine in modelled scenarios	Physical models; contested	New START lapsed in February 2026; about 12,200 warheads
Engineered or severe natural pandemic	Tens of millions to far more, depending on lethality	COVID-19 precedent; expert judgement	Pathogen-sharing annex unfinished in 2026
Advanced AI	Unknown	Surveys; no empirical base	International AI Safety Report 2026
Extreme climate outcomes	Hundreds of millions of people outside historical conditions at upper-range warming	Scenario studies	Warming path 2.3 to 2.8 °C, with overshoot of 1.5 °C very likely (UNEP)
Natural hazards (supervolcano, asteroid)	Potentially very large, very low probability	Geological record	Low and stable; the only tail not rising

Qualitative comparison by H Heuristics from the sources cited in the text. Not a ranking by probability.

10.6 What this means for the survival question

The tail has three implications. First, the probability of extinction in this century is probably small but not negligible, and neither the experts nor the forecasters agree on how small. Second, the tail is dominated by weapons and pathogens, which are not what most people mean when they speak of the polycrisis; the policy implication is that a climate and development agenda is necessary for survival but not sufficient. Third, the tiers interact. A world that fails on Tier I, with weak health systems, high hunger and fragile states, is a poor place to withstand a Tier II shock. A world that succeeds on Tier I is better placed. It is useful to think of the Tier I agenda as buying resilience to the tail, and the tail agenda as buying insurance against a failure of resilience, and to fund both.

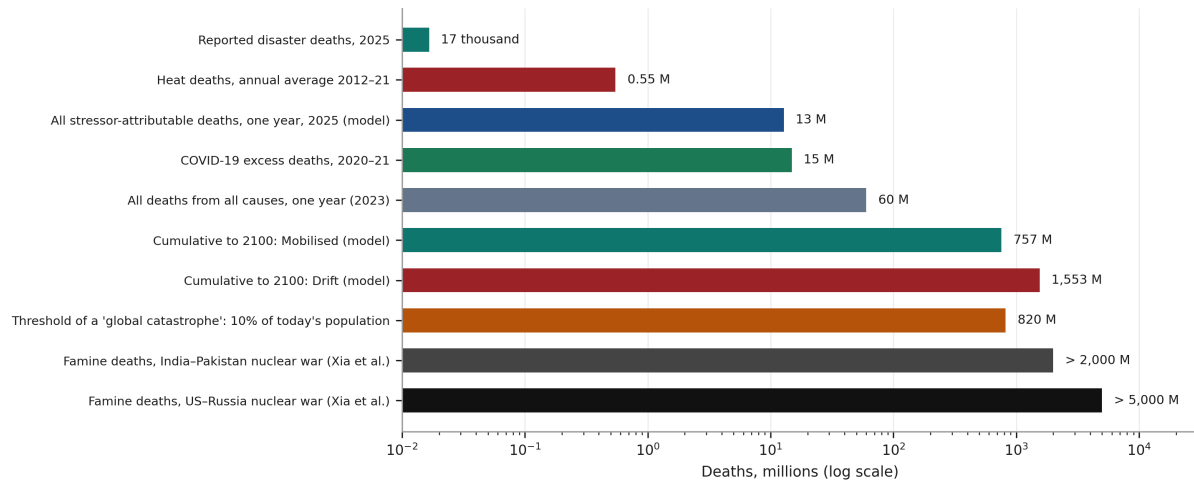


Figure 18. The scale of mortality events: from a year of reported disasters to the nuclear-famine scenarios (log scale).

Sources: [EM-DAT](#); [Lancet Countdown](#); [WHO](#); [GBD 2023](#); [Xia et al. \(2022\)](#); H Heuristics model. Grades A to D as marked in the text; model bars are cumulative or annual attributable deaths, not forecasts.

11. What Reduces Risk: An Evidence-Ranked Portfolio

The model says where the avoidable deaths are. This section asks what works to avoid them. The answer is a portfolio, not a flagship: the measures that save the most lives are well understood, mostly cheap relative to their benefits and largely complementary.

11.1 Ranking measures by lives and by evidence

Table 7 ranks the measures that act on the pathways in Section 3, combining the model's estimate of the share of avoided deaths with the strength of the empirical evidence that the measure works. The ranking is a judgement, but its two components are explicit. Where the model's share is large and the empirical evidence is strong, as for clean air, the case is secure. Where the model's share is small but the evidence is strong and the cost low, as for early warning, the case rests on benefits the model does not count. Where the evidence is weak, as for tail-risk governance, the case rests on the size of the consequence rather than on measured returns.

Table 7. An evidence-ranked portfolio of risk-reduction measures

Measure	Pathway	Share of modelled avoided deaths	Evidence that it works
Clean power and clean cooking	Air pollution; climate	≈ 55%	Strong. 7.9 million deaths a year are attributed to air pollution, 2.8 million of them to household smoke (HEI); fossil-fuel particles alone account for about 8.7 million
Infection prevention and antimicrobial stewardship	Antimicrobial resistance	≈ 15%	Moderate. GRAM authors report that better infection prevention, access to care and new antibiotics could avert a large share of the forecast 39 million deaths
Peace and state capacity	Conflict and fragility	≈ 11%	Moderate. Record 65 state-based conflicts in 2025 (UCDP); indirect deaths are poorly measured
Food, water, primary care and nutrition	Hunger and infection	≈ 11%	Strong for the basics: under-five deaths halved since 2000 (UN IGME); 2.1 billion still lack safe water (WHO/UNICEF)
Heat action plans, cooling access, urban design	Heat	≈ 7%	Moderate to strong. Ahmedabad plan associated with about 1,100 to 1,190 deaths avoided a year; Europe records 62,775 heat deaths in summer 2024 (ISGlobal)
Multi-hazard early warning and shelters	Extreme events	< 1% of lives; large for losses	Strong. Bangladesh cyclone deaths fell from hundreds of thousands to fewer than 30 in a comparable event (UNDRR); disaster mortality is about six times higher where coverage is limited
Rapid emissions cuts	Heat, food, tipping points; hazard in all	Included in the hazard side	Strong on direction: exposure to dangerous heat at 1.5 degrees is less than a quarter of that at 2.7; UNEP shows pledges still short
Pandemic preparedness and biosecurity	Tail; infection	Not modelled	Weak to moderate. 14.9 million excess deaths in COVID-19; pathogen-sharing annex unfinished
Arms control and de-alerting	Tail	Not modelled	Weak (models only). Famine could kill billions in modelled nuclear war (Xia et al.); New START lapsed

Shares are the median shares of deaths averted in the mobilised world relative to drift, by pathway (Section 9); the vulnerability and hazard levers that act on each pathway are grouped. Evidence statements are by H Heuristics.

11.2 Clean air is the first move

The model and the empirical literature agree on one point more strongly than on any other: the single largest lever on mortality in the next fifty years is the reduction of fine-particle pollution from fossil-fuel combustion and solid-fuel cooking. It is also the point at which the climate and health agendas have the strongest overlap, because the same actions, replacing coal and diesel and giving households modern cooking, cut carbon dioxide, methane and black carbon and cut deaths. The benefits are comparatively quick, visible and local: the share of global deaths attributed to fine particles from fossil fuels fell from 21.5 per cent in 2012 to 18 per cent in 2018, largely because of air-quality measures in China, according to the [Harvard analysis](#) cited above. For governments weighing the cost of mitigation against other priorities, the health benefit alone can be a sufficient justification.

11.3 Early warning, heat plans and the cheap defences

The measures that save the most lives per dollar are not the ones that make headlines. The [Global Commission on Adaptation](#) estimated that US\$1.8 trillion invested globally between 2020 and 2030 in early warning, resilient infrastructure, dryland agriculture, mangroves and water resources could generate US\$7.1 trillion in net benefits, with benefit-cost ratios from about 2:1 to 10:1. Early-warning coverage is growing but uneven: [119 countries, about 60 per cent, report multi-hazard systems](#), against 43 per cent of small island developing states. The UN Secretary-General's [Early Warnings for All](#) initiative aims for universal coverage by the end of 2027, one of the near-term markers in Figure 20.

Heat is the most neglected of these defences. Disasters have visible damage and a recognisable emergency response; heat deaths are quiet, concentrated among the old and poor and often reclassified as cardiovascular. Low-cost interventions, including heat-health warning systems, cooling centres, reflective roofs, tree cover, outreach to isolated older people and labour rules for outdoor workers, have been evaluated in a few places, such as Ahmedabad, with encouraging results. The case for scaling them is strengthened by the ageing result in Section 9: heat will kill more people in an older world, whatever happens to warming.

11.4 Health systems, nutrition and infection control

Progress against child mortality and infectious disease shows that systems built for ordinary disease are the foundation of resilience to extraordinary shocks. The model gives the largest weight in the infection-and-undernutrition channel to the pace of vulnerability reduction, which is a proxy for investment in primary care, vaccination, nutrition and water. The measure that links this channel to the tail is antimicrobial stewardship, which protects the efficacy of the drugs on which routine care depends. The stake is large, with about 39 million deaths forecast between 2025 and 2050 without further action, and the interventions, from infection prevention in hospitals to limits on non-human use of antibiotics, are largely within the reach of national governments.

11.5 Peace, arms control and the tail

The tail measures are justified, as insurance is, by the size of the loss rather than by measured returns. Restoring the architecture of nuclear arms control, reducing the number of warheads on high alert, completing the pathogen-sharing annex and the Pandemic Agreement, strengthening biosecurity screening for synthetic DNA and building independent evaluation of frontier AI systems are the measures with the strongest rationale.

12. Governance, Finance and the Delivery Problem

The most robust finding of the previous sections is that large lives-saved dividends are available at modest cost. The most troubling finding is that the resources and institutions needed to collect them are weakening.

12.1 The adaptation and aid gap

The UNEP [Adaptation Gap Report 2025](#) estimates that developing countries will need about US\$310 billion a year by 2035 for adaptation on modelled costs, and about US\$365 billion on the basis of their own national plans, while international public adaptation finance was about US\$26 billion in 2023, down from US\$28 billion the previous year. The gap, of the order of 12 to 14 times current flows, is not a measure of the money required to avoid every adverse outcome; it is the cost of implementing what countries have said they need. Meanwhile the main source of concessional finance is shrinking. The OECD reports that [official development assistance fell 23.1 per cent in real terms in 2025](#), to US\$174.3 billion, with the United States accounting for about three-quarters of the decline, and projects further falls.

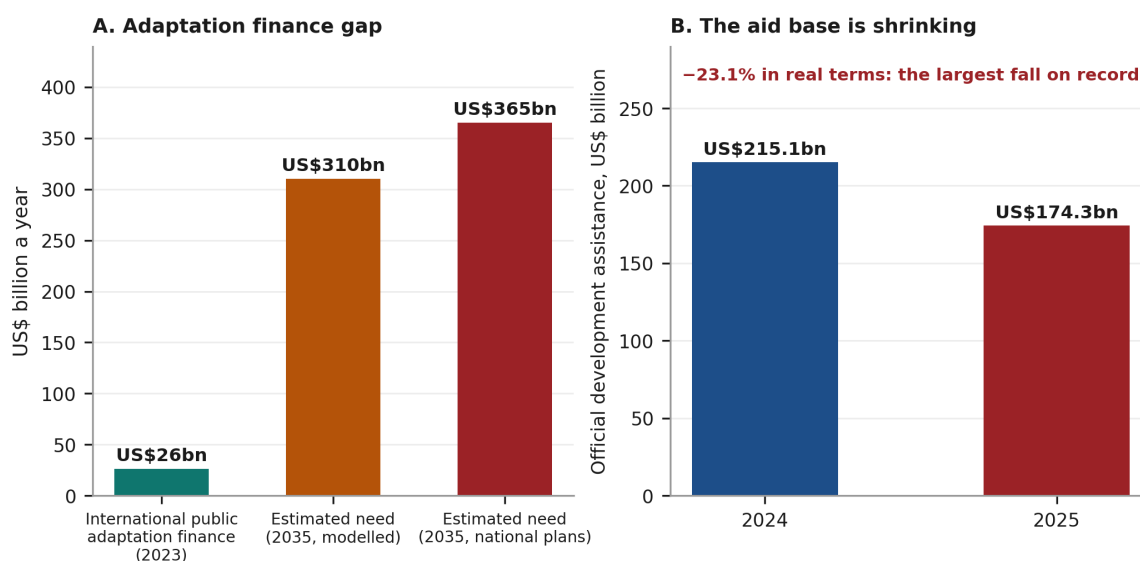


Figure 19. Finance gaps. Panel A: international public adaptation finance compared with estimated needs in 2035. Panel B: official development assistance in 2024 and 2025.

Sources: [UNEP Adaptation Gap Report 2025](#); [OECD](#). Grade A (flows) and C (needs).

12.2 Why delivery matters more than design

The model's amplification term is a way of representing delivery risk: in the drifting world, the same stresses that raise mortality also weaken the ability of governments and agencies to respond, so that mortality rises more than the hazard alone would imply. The sensitivity analysis shows that the strength of that coupling is the second-most important uncertainty in the estimate of deaths averted. The practical implication is that a strategy designed for a benign delivery environment is a fragile strategy. Programmes whose success depends on continuous external funding, on the political stability of the recipient or on the goodwill of every major power should be assumed to fail some of the time, and the portfolio should be designed to continue to work when they do.

12.3 Design principles for a robust survival portfolio

- **Prefer measures that work without continuous funding.** Capital-intensive defences, such as shelters, sea walls, clean power and water systems, keep working when budgets are cut; recurrent programmes do not. The balance should tilt toward the former where they exist.
- **Pre-arrange the money.** Finance that is committed before a shock reaches people faster and at lower cost than finance negotiated after it. Contingent credit, parametric insurance and debt-pause clauses for disasters belong in the standard toolkit.
- **Concentrate on the countries and groups with the highest vulnerability.** Sub-Saharan Africa and South Asia carry most of the avoidable burden (Figure 7), and the population wave described in Section 5 means the requirement will rise.
- **Link health and climate budgets.** Air quality, heat and infection are health problems that climate policy and finance can solve, and the two agendas should be funded and scored jointly.
- **Measure what matters.** A system that does not count deaths from heat or indirect conflict mortality will not reduce them. Section 13 proposes a small set of indicators.
- **Keep the tail on the agenda.** Investments in arms control, biosecurity and AI governance are cheap relative to their potential benefit, and they should not be crowded out by the more measurable Tier I agenda.

12.4 Institutions in 2026

The institutions are being tested. The Paris Agreement process continues, with a [UNEP assessment](#) that new pledges had barely moved the projection and with only 60 parties, covering 63 per cent of emissions, having submitted new 2035 targets at the time of the report. The WHO Pandemic Agreement awaits its annex. The nuclear arms-control architecture has lost its principal treaty. The aid system has lost nearly a quarter of its real volume in a year. None of this is irreversible, but all of it points in the same direction, which is why the central result of this report is about delay: the world is currently choosing, by default, between muddling through and drift.

13. A Strategic Pathway, 2025 to 2100

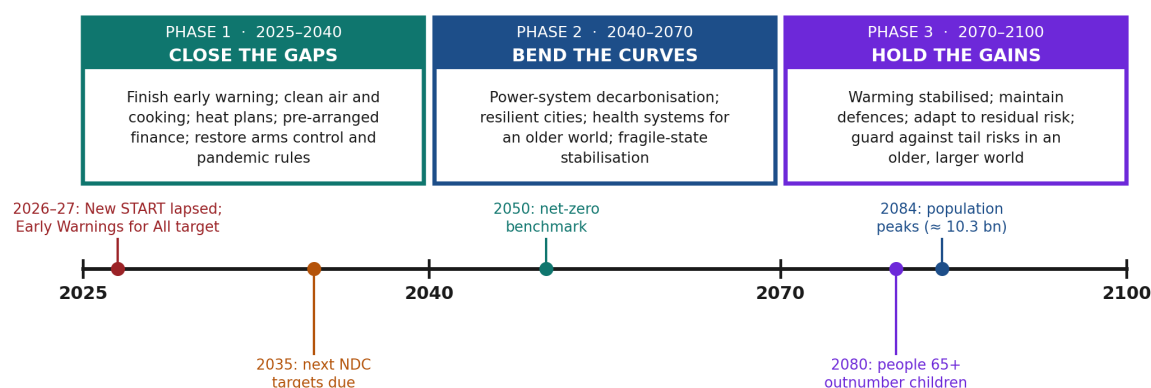
A century is too long to plan and too short to ignore. The pathway below divides it into three phases, each with a different task, and ends with a small set of indicators that would tell the world whether it is on the mobilised, muddling or drifting trajectory.

13.1 Three phases

Phase 1, 2025 to 2040: close the gaps. The task is to complete what is known to work and has been left unfinished. Complete multi-hazard early warning, with heat included. Scale clean cooking and clean power in the countries with the highest household and ambient pollution. Adopt heat action plans in the cities that have none. Pre-arrange disaster finance. Restore nuclear arms control and finish the pandemic annex. Build the survival ledger. The model suggests that this phase carries the greatest leverage: every year of delay in these actions costs about 14 million deaths by 2100.

Phase 2, 2040 to 2070: bend the curves. The task is to bring the large systems into line. Decarbonise power and transport so that warming stabilises. Design cities and housing for heat and flood. Reorient health systems toward the care of an older population, with chronic disease and dementia care at the centre. Stabilise fragile states. This is the period in which the muddling-through world's deaths plateau and the drifting world's rise, and in which most of the divergence between worlds is created.

Phase 3, 2070 to 2100: hold the gains. The task is to maintain defences against residual risk in a world that is older, at or just past its population peak, and living with the warming it has chosen. People aged 65 and over will outnumber children under 18 from about 2080. The tail risks, which are unaffected by warming, will remain. The great risk of this phase is complacency: the capacity to prevent the deaths this report counts is not self-sustaining.



Timeline not to scale. In the model each year of delay in Phase 1 costs about 14 million lives by 2100.

Figure 20. A three-phase pathway to 2100, with near-term and long-run markers. The timeline is not to scale.

Source: H Heuristics. Illustrative roadmap. Markers: [New START lapse](#); [UN population projections](#); the 2050 net-zero benchmark is the IPCC-consistent mid-century target.

13.2 A survival dashboard

Table 8 proposes a short dashboard of indicators for which data already exist, each with its latest value and the direction that would indicate progress. It is meant to be updated annually, and read as a whole: a world that is making progress on the first column and slipping on the second is heading for muddling through.

Table 8. A survival dashboard: indicators, latest values and desired direction

Indicator	Latest value	Desired direction	Source
Air-pollution deaths	7.9 million (2023)	Falling	HEI
Heat-related deaths (annual average)	≈ 546,000 (2012–21)	Falling	Lancet Countdown
Under-five deaths	4.9 million (2024)	Falling	UN IGME
People hungry	≈ 645 million (2025)	Falling	SOFI 2026
People without safely managed water	2.1 billion (2024)	Falling	WHO/UNICEF
Countries with multi-hazard early warning	119, about 60% (2025)	Rising to all	WMO
International adaptation finance	US\$26 billion (2023)	Rising toward needs	UNEP
Official development assistance	US\$174.3 billion (2025)	Stabilising	OECD
State-based conflicts	65 (2025)	Falling	UCDP
Forcibly displaced people	117.8 million (end-2025)	Falling	UNHCR
Global warming above pre-industrial	≈ 1.4–1.55 °C (2024–25)	Peaking, then falling	WMO
Nuclear warheads (total inventory)	≈ 12,187 (Jan 2026)	Falling	SIPRI
Pandemic-agreement annex	Under negotiation (2026)	Agreed and ratified	WHO

Values as cited in the text. Several series are not yet measured consistently, notably heat deaths outside Europe and indirect conflict mortality.

14. Conclusions and Priorities

Humanity is very unlikely to be wiped out by the polycrisis, and it is very likely to lose several hundred million people to causes that are largely preventable. The first sentence is not a reason for comfort; the second is a reason for action.

14.1 What the evidence says

Four conclusions stand out. First, the measurable survival problem of the century is chronic, not catastrophic: air pollution, hunger and infection, heat, conflict and antimicrobial resistance dominate, and disasters, the events that dominate headlines, account for under one per cent of the burden. Second, vulnerability is as important as hazard. The countries and groups with the least capacity suffer the most, vulnerability can fall quickly, as Bangladesh's cyclone record shows, and the most important determinant of the future burden is how much is invested in lowering it. Third, demography changes the arithmetic. An older world will lose more people to the same exposure, and that makes every defence more valuable. Fourth, the tail is not about climate: the greatest sources of catastrophic risk are weapons and pathogens, and the institutions that govern both are weakening.

The model puts numbers on the first three conclusions, with caveats. A mobilised world would avoid about 380 million deaths relative to muddling through and about 790 million relative to drift over the century, about half through cleaner air. A ten-year delay costs about 140 million lives. The ranges and the sensitivity analysis suggest the conclusions are robust in direction and uncertain in size.

14.2 Eight priorities

- **1. Make clean air the first move.** Treat air quality as the entry point to mitigation: accelerate the retirement of coal and diesel, extend clean cooking to the households whose smoke causes 2.8 million deaths a year, and score climate finance by the lives it saves.
- **2. Treat heat as a mortality emergency.** Require heat action plans in every city above a population threshold, extend cooling access, and count heat deaths as routinely as road deaths.
- **3. Finish early warning.** Deliver the Early Warnings for All target, add heat and flood to the systems already in place, and link warnings to shelters and cash transfers.
- **4. Protect the aid and adaptation base.** Stabilise official development assistance, close the adaptation finance gap in the highest-vulnerability countries and pre-arrange disaster finance.
- **5. Build health and food systems that hold in a shock.** Prioritise primary care, nutrition and safe water, and prepare contingency plans for food-price shocks of the kind the 2026 energy crisis threatens.
- **6. Defend the drugs and the treaty.** Fund antimicrobial stewardship and finish the pathogen-sharing annex so that the Pandemic Agreement takes effect.
- **7. Restore the nuclear guardrails.** Resume US–Russia strategic arms control, widen it to other nuclear states and reduce the number of warheads on high alert.
- **8. Build the survival ledger.** Adopt the dashboard in Table 8 as a standard, publish it annually, fund independent audit and replace this model with better ones.

14.3 What would change this report's mind

A report that cannot be wrong is not useful. The conclusions here would need revising if any of the following were shown. If cohort-level evidence showed that the fall in air-pollution mortality associated with cleaner fuels were much smaller than assumed, the largest source of avoided deaths would shrink and the case for mitigation would rest more on heat, food and the tail. If evaluations showed that heat action plans had no effect on mortality once secular trends were controlled, the heat result and its policy implication would weaken. If the true coupling between systems were much stronger than assumed, the gap between worlds would be larger and the case for acting early stronger. If mortality from non-communicable disease continued to fall faster than assumed, all three worlds would be better and the gaps smaller. And if the tail probabilities that experts report were substantially lower, the case for tail-risk governance would weaken, though not disappear.

14.4 Limitations

The report is a synthesis and a model, with the limits of both. The sources are secondary or tertiary in some cases, as noted in the text, and several figures are reported in press summaries of studies whose full text could not be consulted; where that is so, the link goes to the source consulted. The model is an accounting device, not a forecast, and its parameters are assumptions. It counts attributable rather than excess deaths, uses overlapping pathways and does not represent costs, tipping points or tail events. The tail estimates are expert judgements. The report contains no investment advice and no endorsement of any particular policy beyond the evidence cited. It was finalised in October 2026; events after that date are not reflected, and the 2026 energy shock described in Section 4 was ongoing when the underlying sources were consulted.

Appendix A. Model Specification

This appendix gives the equations and parameter distributions of the Survival Exposure–Vulnerability Model so that every result in Sections 9 and 11 can be reproduced.

A.1 Equations

For pathway c , world s and year t (2025 to 2100), annual attributable deaths in millions are $D(c, s, t) = B(c) \times X(c, t) \times H(c, s, t) \times V(c, s, t) \times \varphi(c, s, t)$, with the following definitions. Warming above today is $\Delta T(s, t) = \kappa \times (T(s, t) - 1.45)$, where T is the scenario path in Figure 4 and κ is a climate scaling draw. Heat: $H = 1 + \beta_{\text{heat}} \Delta T + q \Delta T^2$. Hunger and infection: $H = 1 + \beta_{\text{nut}} \Delta T$. Extreme events: $H = 1 + \beta_{\text{ext}} \Delta T$. Air pollution: $H = 1 - c_s u \times \text{ramp}(t)$, where ramp is a logistic function centred on 2045 with a width of nine years, normalised to zero in 2025. Conflict: H interpolates linearly between 1.0 in 2025, a 2060 value and a 2100 value for each world, with the deviation from 1.0 scaled by a lognormal draw. Vulnerability: $V = \exp(-g(c, s) \times u_g \times (t - 2025))$, where $g(c, s) = g_{\text{drift}} + (g_{\text{world}} - g_{\text{drift}}) \times u_{\text{gap}}$. Amplification: $\varphi = 1 + k(s) \times u_k \times \min(\Delta T/1.5, 1.5) \times \min(1, (t - 2025)/40)$, applied to hunger and infection, extreme events and conflict. Conflict deaths are $0.245 \text{ million} \times (1 + m)$ in 2025, with m the indirect-to-direct ratio.

Table A1. Baselines and exposure indices

Pathway	Baseline 2025 (million deaths a year)	Exposure index (2025 = 1.0)
Air pollution	7.9	$0.85 \times \text{age } 65+ (1.00 \rightarrow 1.75 \text{ in } 2050 \rightarrow 2.60 \text{ in } 2100) + 0.15 \times \text{under-five cohort } (1.00 \rightarrow 0.95 \rightarrow 0.85)$
Heat	0.60	$0.7 \times \text{age } 65+ + 0.3 \times \text{total population } (1.00 \rightarrow 1.19 \text{ in } 2050 \rightarrow 1.25 \text{ in } 2100)$
Hunger and infection	2.0	$0.6 \times \text{under-five cohort} + 0.4 \times \text{total population}$
Extreme events	0.065	Floodplain and coastal population: $1.00 \rightarrow 1.25 \text{ in } 2050 \rightarrow 1.45 \text{ in } 2100$
Conflict and fragility	0.245 direct; $\times (1 + m)$ with m between 1 and 5 (mode 3)	Total population
Antimicrobial resistance	1.25 (2025), rising to $1.91 \times \text{scenario factor}$ in 2050	Not applicable (follows reference forecast)

Demographic indices are assumptions informed by the UN World Population Prospects 2024 and are varied (65+ growth scaled 0.85 to 1.15).

Table A2. Uncertain parameters and their distributions

Parameter	Distribution (low, mode, high)	Applies to
β_{heat} : sensitivity of heat deaths to warming (per degree)	Triangular (0.25, 0.45, 0.80)	Heat
q : curvature of heat response	Triangular (0.05, 0.20, 0.40)	Heat
β_{nut} : sensitivity of hunger and infection to warming	Triangular (0.05, 0.10, 0.25)	Hunger and infection
β_{ext} : sensitivity of extreme-event deaths to warming	Triangular (0.10, 0.25, 0.50)	Extreme events

Parameter	Distribution (low, mode, high)	Applies to
m: indirect-to-direct conflict deaths	Triangular (1, 3, 5)	Conflict and fragility
k: scale on warming above today	Normal (1.0, 0.15), truncated 0.6 to 1.5	All warming-driven channels
u_g: scale on vulnerability decline rates	Lognormal, $\sigma = 0.25$	All vulnerability terms
u_air: scale on air-pollution cut	Normal (1.0, 0.15), truncated 0.6 to 1.3	Air pollution
u_k: scale on amplification strength	Lognormal, $\sigma = 0.35$	Amplified channels
u_gap: scale on the difference in vulnerability decline between worlds	Fixed at 1.0; varied 0.5 to 1.5 in sensitivity	All vulnerability terms
u_amr: scale on antimicrobial-resistance level	Lognormal, $\sigma = 0.20$	Antimicrobial resistance
u_conf: scale on conflict deviation	Lognormal, $\sigma = 0.15$	Conflict and fragility
65+ growth scale	Triangular (0.85, 1.0, 1.15)	Age-based exposure

20,000 draws; the same draws are used in every world. Delay scenarios keep the Drift settings for the lag period and switch to Mobilised settings thereafter, with warming raised by 0.02 degrees per year of delay, ramped over 30 years.

Appendix B. Sources by Theme

Every quantitative claim in the report is linked inline. This appendix groups the principal sources by theme for reference. Grades follow Table 1. Where only a secondary summary could be read, both are listed.

Climate and hazards

- UNEP, [Emissions Gap Report 2025](#) and [Adaptation Gap Report 2025](#); WMO, [2025 climate update](#); [Climate Action Tracker](#); [IPCC AR6](#).
- Lenton, T. et al., [Quantifying the human cost of global warming](#), *Nature Sustainability* (2023) and the [authors' release](#); Hultgren, A. et al., [crop yields with adaptation](#), *Nature* (2025); Kulp, S. and Strauss, B., [coastal vulnerability to sea-level rise](#) (2019).
- [Global Tipping Points Report 2025](#); [Planetary Health Check 2025](#); FAO on the [Strait of Hormuz crisis](#).

Mortality and health

- HEI, [State of Global Air 2025](#); Vohra, K. et al., [fossil-fuel particles and mortality](#); Pozzer, A. et al., [Atmospheric health burden across the century](#), *Nature Communications* (2024).
- [Lancet Countdown 2025](#) and [UCL summary](#); ISGlobal on [European heat deaths](#); Bressler, R., [The mortality cost of carbon](#) (2021); Carleton, T. et al., [Valuing the global mortality consequences of climate change](#) (2022); WHO, [Quantitative risk assessment](#).
- [UN IGME child mortality](#); [GBD 2023 findings, as reported by Health Policy Watch](#); [SOFI 2026](#); WHO/UNICEF [JMP 2025](#); [GRAM antimicrobial-resistance forecast](#); WHO, [COVID-19 excess mortality](#).

Demography, exposure and displacement

- UN, [Our growing population](#) (World Population Prospects 2024) and [data portal](#); World Bank, [Groundswell Part 2](#); [UNHCR Global Trends](#); [IDMC, Global Report on Internal Displacement 2026](#); World Bank, [poverty overview](#).

Disasters, conflict and the tail

- [EM-DAT 2025 report](#); UNDRR on [Bangladesh cyclone preparedness](#) and the [Red Cross account of Amphan](#); WMO, [Early warning systems](#); [Global Commission on Adaptation, Adapt Now](#); [Ahmedabad heat action plan](#).
- Uppsala Conflict Data Program, [Conflict trends 2025](#); Mach, K. et al., [Climate as a risk factor for armed conflict](#), *Nature* (2019).
- Xia, L. et al., [Global food insecurity and famine from nuclear war soot](#), *Nature Food* (2022) and [press summary](#); [SIPRI Yearbook 2026](#), [World nuclear forces](#); Chatham House on [New START](#).
- Forecasting Research Institute, [Existential Risk Persuasion Tournament](#) and [near-term accuracy report](#); Ord, T., [The Precipice](#) (2020); Kemp, L. et al., [Climate Endgame](#), *PNAS* (2022); Grace, K. et al., [Thousands of AI authors on the future of AI](#); [International AI Safety Report 2026](#); WHO, [pathogen-sharing annex negotiations](#).

Finance and institutions

- OECD, [preliminary official development assistance 2025](#); Lawrence, M. et al., [Global polycrisis: the causal mechanisms of crisis entanglement](#) (2024); WEF, [Global Risks Report 2026](#); UNDRR, [Global Assessment Report 2025](#).