



RESEARCH SERIES · REPORT 01 · POLYCRISIS RESILIENCE

How Many Lives Could Polycrisis Resilience Save This Century?

A scenario analysis of proactive resilience, clean transition and sustainable development in the Global South, 2025–2100

368M

net deaths averted, 2025–2100

13.6B

healthy life-years gained

1.9B

fewer people severely deprived by 2050

About this report

H Heuristics Research turns complex-systems questions into transparent, auditable estimates that decision-makers can interrogate. This first report in the Polycrisis Resilience series asks a deliberately large question: if the world acts early and together on clean energy, health, water, food, climate adaptation and development in the Global South, how many lives could be saved, how many healthy years preserved, and how many people lifted out of severe deprivation or protected from compounding shocks between 2025 and 2100?

The answer is built on a purpose-made scenario model, HH-PRM v1.0, that compares four futures: reactive drift, delayed action, siloed progress and coordinated resilience. Every number in this document is computed by that model from stated assumptions, and each assumption is registered in Appendix A with its evidence grade.

READ THIS BEFORE RELYING ON ANY NUMBER

These are scenario estimates, not forecasts. They answer “what difference could action make, under explicit assumptions?” not “what will happen?”. The model is parametric and global-to-regional; it is not a country-level epidemiological model and has not been peer reviewed. Where the evidence base is thin we say so, and we report uncertainty ranges rather than single answers.

Data vintage differs by indicator. The 2025 baseline combines the latest available published figures, which refer to years between 2019 and 2024. Regional allocation weights and several baseline splits are H Heuristics working assumptions informed by published distributions; they are flagged as such.

Sources. Headline figures were checked against publisher pages or summaries in October 2026. Several were confirmed through secondary coverage only, and a few are cited from prior knowledge; the grade for each is shown in Appendix D. Check the primary text before external citation.

HOW TO CITE

H Heuristics Research (2026). *How Many Lives Could Polycrisis Resilience Save This Century? A scenario analysis, 2025–2100*. Polycrisis Resilience Series, Report 01, version 1.0.

CONVENTIONS

- **Deaths averted** are net of overlap between risk factors and of interaction effects, measured against the Reactive drift scenario, 2025–2100, undiscounted, unless stated otherwise.
- **Healthy life-years** are disability-adjusted life-years (DALYs) averted. Costs are in constant 2025 US dollars; present values use a 3% real discount rate.
- **Intervals** are 90% Monte Carlo intervals (5th to 95th percentile) from 5,000 joint draws of the uncertain parameters. “Central” denotes the deterministic run at central parameter values.
- **Global South** is used as shorthand for low-, lower-middle- and upper-middle-income countries.

Contents

Executive summary	5
1. The question that frames the century	
PART I · FRAMING	
2. The anatomy of the polycrisis	
3. How the model works	
4. The baseline: what is at stake without new action	
PART II · THE BASELINE	
5. Clean energy and air quality	
PART III · THE RESILIENCE PATHWAYS	
6. Water, sanitation and food	
7. Health systems, infectious disease and pandemics	
8. Climate adaptation and mitigation	
9. Development convergence and the Global South	
10. Lives saved	
PART IV · RESULTS	
11. Healthy life-years gained	
12. Lives improved: deprivation and resilience	
13. Who benefits: region, income and generation	
14. Cost, finance and value for money	
15. Uncertainty, sensitivity and stress tests	
16. What efficient leadership looks like	
PART V · IMPLICATIONS	
17. The cost of waiting	
18. Limitations and research agenda	
Appendix A · Parameter register	56
APPENDICES	
Appendix B · Allocation weights and demography	
Appendix D · Source register	60

Figures

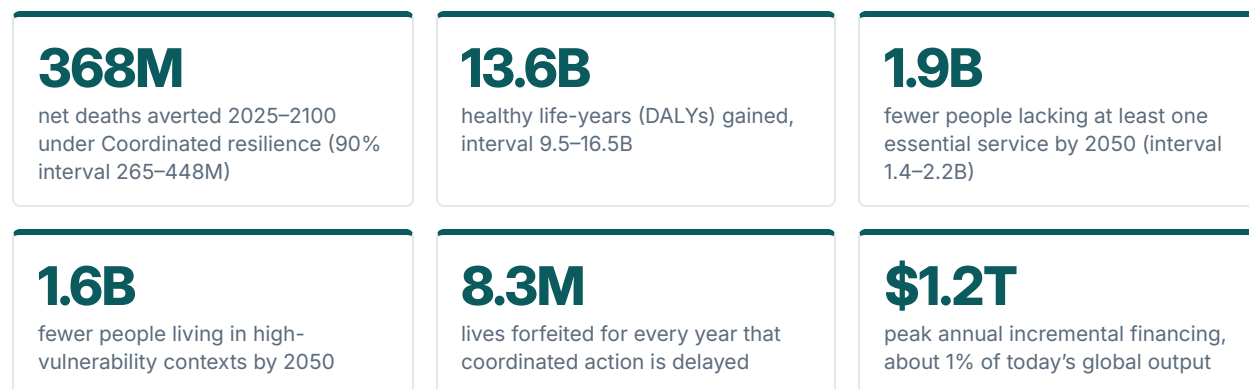
1	Coordinated resilience averts about 60% more lives than either delay or siloed action	6	17	About 21% of the gross total is removed as overlap and interaction	33
2	Five stress pathways convert root drivers into deaths, deprivation and fragility	9	18	Coordinated resilience gains 13.6 billion healthy life-years	35
3	Scenarios differ in when action starts and how much of it is delivered	13	19	By 2050 coordinated resilience leaves 0.9 billion people deprived, against 2.8 billion otherwise	37
4	Population growth after 2050 is concentrated in Sub-Saharan Africa and South Asia	15	20	Sanitation, clean cooking, health coverage and water account for the largest gains	38
5	Air pollution and amenable health deaths dominate the baseline burden	16	21	Without action the highly vulnerable population grows to about 4 billion; with action it halves	39
6	Billions of people lack the services that underpin resilience	17	22	Sub-Saharan Africa and South Asia receive three-fifths of the lives saved	40
7	Under reactive drift the attributable burden stays above 20 million a year until about 2070	18	23	Lives saved build over time, mostly in low- and lower-middle-income countries	41
8	Coordinated resilience cuts air-pollution deaths by 40% below the reactive path by the 2060s	20	24	Children under five receive about 20% of lives saved; people over 65 about 42%	42
9	Water and nutrition deaths fall fastest under coordinated action	22	25	Financing peaks near \$1.2 trillion a year, led by clean energy and adaptation	43
10	Quality health systems cut amenable deaths by about a third relative to the reactive path	24	26	Health benefits alone roughly repay the programme; Delayed action does not	45
11	Preparedness halves the chance of a catastrophic pandemic century	25	27	Coordinated resilience outperforms the alternatives across the plausible range	46
12	Mitigation and adaptation each bend the climate-mortality curve	27	28	Delivery capacity and the baseline rate of progress matter most	47
13	Adaptation delivers more lives this century; mitigation protects the long term	28	29	Even partial or delayed delivery averts more than 200 million lives	47
14	Every service gap closes faster under coordinated action, with the largest differences before 2060	30	30	Ten actions, two horizons: scale up now, build out from 2028	51
15	Annual lives saved peak at 6.6 million around 2071	31	31	Every year of delay costs about 8.3 million lives over the century	52
16	Coordinated resilience pulls away from the alternatives after 2050	32			

Tables

1	The four outcome ledgers	8	13	Financing components, peak annual need and present value	44
2	Stress pathways, mechanisms and evidence anchors	10	14	Cost per discounted DALY averted by pathway (health-only attribution)	45
3	Scenario definitions	12	15	Stress tests	47
4	Overlap discounts by pathway	14	16	Ten priority actions for the first decade	50
5	Baseline anchors used in the model	16	17	Waypoints implied by Coordinated resilience	51
6	Clean energy and air quality: key assumptions	19	18	Lives forfeited by delay	53
7	Water and nutrition: key assumptions	21	19	Planned improvements	55
8	Health systems: key assumptions	23	20	Mortality pathway parameters (central values)	56
9	Closing the gaps: people deprived of each service, billions	30	21	Scenario scaling of the Coordinated ceilings	56
10	Deaths averted by pathway under Coordinated resilience, 2025–2100, millions	32	22	Deprivation services	57
11	Results by scenario, 2025–2100	33	23	Regional population and allocation weights	58
12	DALYs per death averted and totals under Coordinated resilience	35	24	Net deaths averted by decade, millions	59

Executive summary

Acting early, together and at scale could avert roughly 368 million deaths this century. Waiting, or acting in silos, forfeits more than a third of that prize.



The central question of this report is **how much difference proactive polycrisis resilience could make by 2100**. We define resilience broadly: clean energy and air quality, safe water and sanitation, food and nutrition security, quality health systems, climate adaptation and mitigation, and preparedness for pandemics and compounding shocks, all anchored in sustainable development in the Global South. We compare four futures and track four outcomes: lives saved, healthy life-years gained, severe deprivation reduced and resilience improved.

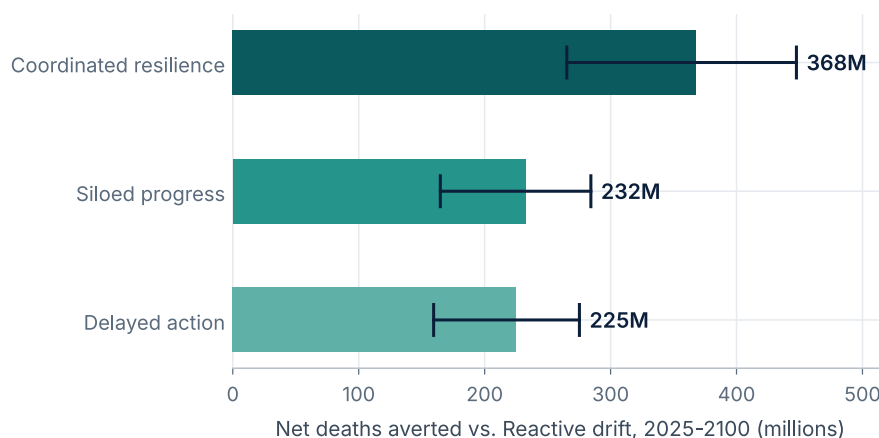
Key findings

- 1 The prize is measured in hundreds of millions of lives.** Coordinated resilience averts about 368 million deaths between 2025 and 2100 relative to reactive drift, with a 90% interval of 265–448 million. That is about 13,000 lives a day averaged across the century, rising to a peak of 6.6 million a year around 2071.
- 2 Benefits are back-loaded, so early decisions carry late payoffs.** Only 58 million of the lives are saved by 2050; 213 million by 2075. Infrastructure, health systems and temperature outcomes lock in over decades, which is why delay is so costly.
- 3 Two-thirds of the benefit accrues to low- and lower-middle-income countries.** Sub-Saharan Africa and South Asia alone account for 62% of lives saved. In Sub-Saharan Africa the model implies about 91 deaths averted per 1,000 people alive in 2025, the highest rate of any region.
- 4 Energy and air quality, and health systems, carry the most lives.** Clean energy and air quality account for 36% of net deaths averted and health systems for 27%. Climate adds 13%, shock preparedness 11%, nutrition 7% and water and sanitation 6%, though the last two deliver the largest *proportional* cuts in their own burdens.
- 5 Timing and integration matter as much as ambition.** Starting 14 years late (Delayed action) delivers 225 million; running well-funded programmes in silos (Siloed progress) delivers 232 million. Each forfeits roughly 135 to 143 million lives, or 37%–39% of the achievable total.

- 6 Lives improved is a separate and larger story.** By 2050 coordinated resilience leaves about 0.9 billion people lacking at least one of six essential services, against 2.8 billion under reactive drift, and cuts the high-vulnerability population by 1.6 billion. These people are not counted as lives saved.
- 7 Health benefits alone roughly repay the investment; the rest is upside.** Present-value net financing is about \$21.8 trillion; present-value health benefits, valued conservatively at \$5,000 per DALY, are about \$21.1 trillion (ratio 0.97, interval 0.55–1.54). Avoided climate damages, energy savings and faster growth are excluded.^{21,31}
- 8 The conclusion is robust to hard tests, but not to inaction.** Delivering only 60% of planned effect still averts about 236 million lives. Combining 60% delivery with an 8-year slip leaves about 211 million. The single most influential uncertainty is delivery capacity, not any scientific parameter.

FIGURE 1 Coordinated resilience averts about 60% more lives than either delay or siloed action

Net deaths averted relative to Reactive drift, 2025–2100, millions; bars show central case, whiskers the 90% Monte Carlo interval



Source: H Heuristics HH-PRM v1.0.

What leaders should do

The evidence points to six commitments that are individually familiar but rarely made together. First, **front-load the unglamorous basics**: clean cooking, electricity access, safe water, primary care and immunisation, because they save the most lives per dollar and unlock everything else. Second, **finance the transition in the Global South**, where the lives are and where the cost of capital is highest; the model requires a peak of about \$1.2 trillion a year of incremental financing, several times today's development assistance.^{3,22} Third, **fund adaptation as a first-order health policy**, starting with early warning and heat resilience in the most exposed countries.^{12,19} Fourth, **build shock absorbers**: social protection and pandemic preparedness that interrupt cascades. Fifth, **govern across silos**: shared targets, shared financing platforms and joint accountability for the outcome metrics in Chapter 16. Sixth, **decide now**: every year of delay costs about 8.3 million lives, roughly 16 every minute.

The question that frames the century

The most consequential decisions about human wellbeing this century will be made in the next decade. This report estimates what they are worth.

Humanity enters the second quarter of the century with unprecedented capacity and unusual fragility. Child mortality has fallen by more than half since 2000, vaccination has saved an estimated 154 million lives over fifty years, and the share of people with access to electricity, clean water and basic health services has risen steadily.^{6,32} Yet 4.9 million children still die before their fifth birthday each year, 7.9 million people die from air pollution, 4.6 billion people lack essential health services, and progress on most indicators has slowed or stalled.^{5,6,7}

Layered over these long-standing deficits are risks that interact. Researchers use the term **polycrisis** for situations in which crises in multiple global systems become causally entangled in ways that significantly degrade humanity's prospects, producing harms greater than the sum of those the crises would cause in isolation.¹ The World Economic Forum's 2026 survey of risk perceptions ranks geoeconomic confrontation first for the year ahead, while over a ten-year horizon environmental risks, led by extreme weather, dominate.² Meanwhile the financial architecture that supports the world's poorest countries is contracting: official development assistance fell by 23.1% in real terms in 2025, to US\$174.3 billion, the largest annual fall on record.³

Why a mortality-based question

Most analysis of the polycrisis stays in the language of risk, resilience and cascades. That language is useful but hard to act on. This report translates it into outcomes that budget holders, ministers and development institutions already use: **deaths averted**, **healthy life-years preserved**, **people gaining essential services** and **people whose exposure or vulnerability falls**. Expressing resilience in human terms forces discipline about what is being claimed, and permits comparison with other priorities.

The scale of what could be at stake is not speculative. A study published in 2025 estimated that sustained cuts to one donor's programmes could cause more than 14 million additional deaths by 2030, against 91 million deaths averted by the same programmes between 2001 and 2021.⁴ The Lancet Commission on Investing in Health estimated in 2013 that a "grand convergence" in infectious, maternal and child health could avert about 10 million deaths in 2035 alone, with benefits exceeding costs by a factor of 9 to 20.³¹ These are the orders of magnitude within which any serious answer must sit.

LIVES SAVED IS NOT LIVES IMPROVED

A policy can substantially improve lives without immediately preventing a death, and a model should not count everyone who receives an improved service as a life saved. This report therefore keeps two ledgers. **Lives saved** counts deaths averted and the healthy years they carry. **Lives improved** counts people who gain essential services or whose exposure to shocks falls. The two are never added together.

The four outcomes tracked

TABLE 1 The four outcome ledgers

Outcome	Core metric	What it counts	What it does not count
Lives saved	Cumulative net deaths averted, 2025–2100	Deaths prevented through cleaner air, safer water, better nutrition, quality care, adaptation and preparedness	Deaths merely postponed by a few years are counted, but at their true life-year value in the DALY ledger
Healthy lives gained	Disability-adjusted life-years (DALYs) averted	Years of life and years of health preserved, including non-fatal illness avoided	Wellbeing gains unrelated to health
Severe deprivation reduced	People gaining electricity, clean cooking, safe water, sanitation, food security and income above the extreme-poverty line	People newly able to meet basic needs; reported per service and as unique persons	Anyone who merely receives a better version of a service they already had
Resilience improved	People whose exposure or vulnerability to compounding shocks falls	Households better protected against heat, flooding and food insecurity through adaptation and social protection	Hazard reduction that does not change a person’s vulnerability

What this report is, and is not

It is a transparent **scenario comparison**. We specify four coherent futures, model their consequences for six mortality pathways and two lives-improved ledgers, adjust for overlap and interaction, and report central estimates with uncertainty. It does not predict the future, set targets for any government, or claim to include every cause of death. Chapter 18 lists what is omitted, almost all of which would increase the estimated benefit.

It is also deliberately **development-centred**. The most robust finding in this literature is that the gains from systemic action are concentrated where baseline deprivation is highest. Sustainable development in the Global South is therefore not one pathway among many; it is the setting in which most of the lives are saved.

HOW TO READ THE REST OF THIS REPORT

Part I frames the question and explains how the model works. Part II sets out the baseline: what is at stake without new action. Part III examines each resilience pathway and its evidence. Part IV presents results on lives saved, healthy years, lives improved, distribution, cost and uncertainty. Part V turns the findings into a leadership agenda. Appendices document every parameter and source.

CHAPTER 2

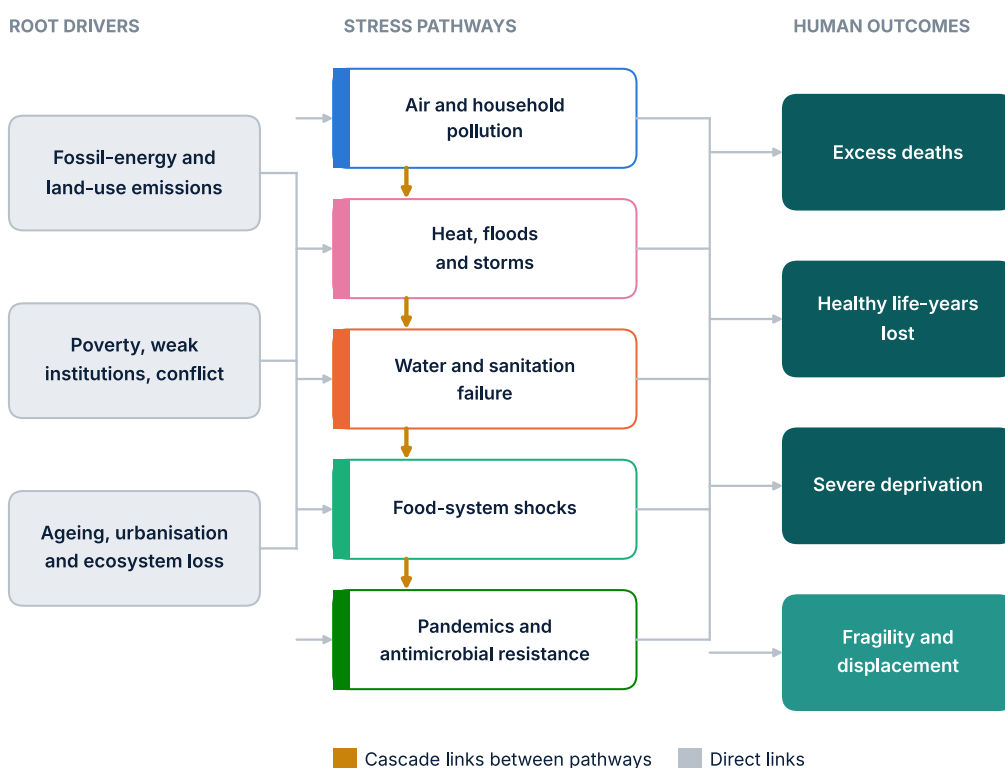
The anatomy of the polycrisis

Crises compound through three channels: shared stresses, domino effects and feedback loops. Resilience investments work by cutting those links.

A polycrisis is more than a list of problems. The causal analysis of Lawrence and colleagues identifies three mechanisms by which crises become entangled: **common stresses** that hit several systems at once, **domino effects** in which failure in one system propagates to another, and **inter-systemic feedbacks** that amplify the original shock.¹ **Figure 2** maps the pathways relevant to human mortality and wellbeing.

FIGURE 2 Five stress pathways convert root drivers into deaths, deprivation and fragility

Conceptual map of the resilience system modelled in this report; amber arrows mark cascade links between pathways



Source: H Heuristics, adapted from the causal framework in Lawrence et al. (2024).

Five pathways, five evidence anchors

Each pathway has a measurable present-day burden, summarised in **Table 2**. Their combined weight, and their tendency to rise together under warming, ageing and fiscal stress, is what makes the resilience question urgent.

TABLE 2 Stress pathways, mechanisms and evidence anchors

Pathway	How it harms	Evidence anchor
Air and household pollution	Fine particles and smoke drive heart disease, stroke, lung disease, cancer and child pneumonia	7.9 million deaths in 2023; 86% from non-communicable diseases; India and China each above 2 million ⁵ . 2.1 billion people lack clean cooking ⁹
Heat, floods and storms	Direct deaths and injury; crop loss; infrastructure failure; displacement	About 546,000 heat-related deaths a year in 2012–21, up 63% since the 1990s ⁸ . 1.81 billion people are exposed to a 1-in-100-year flood, 89% in low- and middle-income countries ²⁰
Water and sanitation failure	Diarrhoeal and respiratory infection, undernutrition, antimicrobial resistance	1.4 million deaths and 74 million DALYs in 2019 ³⁴ . 2.1 billion people lack safely managed water and 3.4 billion safely managed sanitation ¹⁰
Food-system shocks	Hunger, child wasting and stunting, price spikes, political instability	673 million people hungry in 2024; 2.3 billion moderately or severely food insecure ¹¹
Pandemics and antimicrobial resistance	Outbreaks overwhelm health systems; resistant infections defeat treatment	14.9 million excess deaths in 2020–21 ³⁵ . Resistance directly caused 1.14 million deaths in 2021 and is forecast to reach 1.91 million a year by 2050 ³³

Where the pathways meet

Three coincidences deserve emphasis. **Geography:** the people most exposed to heat, flood and food shocks are overwhelmingly the same people who lack clean energy, safe water and quality care. The IPCC assessed that between 3.3 and 3.6 billion people live in contexts that are highly vulnerable to climate change, concentrated in West, Central and East Africa, South Asia, Central and South America and small island states.²⁹ **Demography:** Sub-Saharan Africa's population is projected to grow from about 1.3 billion to about 3.5 billion by 2100, while the share of people aged 65 and over rises from about 10% to about 24% worldwide, which raises exposure to heat and chronic disease.²⁴ **Fiscal stress:** at the moment when needs rise, concessional finance is shrinking.^{3,12}

Evidence that preparedness works is clear when the counterfactual is observed. According to the WMO and UNDRR, disaster mortality is six times higher in countries with limited multi-hazard early warning systems than in countries with comprehensive coverage, and the number of countries reporting such systems has more than doubled since 2015, to 119.¹⁹ The Global Commission on Adaptation estimated that investing US\$1.8 trillion globally from 2020 to 2030 in five adaptation areas could yield US\$7.1 trillion in net benefits, with benefit-cost ratios from 2:1 to 10:1.²¹

Why proactive beats reactive

Three asymmetries make waiting more expensive than acting.

- **Prevention is cheaper than repair.** COVID-19 caused 14.9 million excess deaths in two years; the incremental annual cost of a proper global preparedness system has been estimated at roughly US\$31–34 billion.^{35,36} Reactive spending after a shock is not just later; it is priced at crisis rates.
- **Some damage cannot be undone.** Power plants, grids, buildings and drainage last 30 to 60 years. A child who is stunted at two is permanently affected. Warming committed by emissions today persists for centuries. Late action meets higher committed damage and more stranded assets.
- **Buffers interrupt cascades.** Social protection, early warning and robust primary care do not prevent a drought or an outbreak, but they stop a drought becoming a famine and an outbreak becoming a

regional collapse. Only about half of the world's population has any social protection benefit, and in the 20 countries most vulnerable to climate change the figure is under 9%.²⁸

IMPLICATION FOR THE MODEL

If crises were independent, the benefit of resilience would simply be the sum of sector programmes. Because they are entangled, two things follow: integrated delivery should outperform siloed delivery, and the benefits of different programmes will overlap. The model therefore tests **both** a siloed and a coordinated scenario, and applies explicit overlap and interaction discounts so that benefits are not double counted (Chapter 3).

CHAPTER 3

How the model works

Four scenarios, six mortality pathways, two lives-improved ledgers, explicit overlap discounts and a Monte Carlo that does not understate uncertainty.

HH-PRM v1.0 follows a four-step design: establish the baseline, compare alternative futures, account for interconnected risks, and quantify uncertainty and distribution. It is deliberately simple enough to audit. The structure is shown below and every parameter is registered in Appendix A.

STEP 1 Baseline 2025 attributable deaths by pathway, anchored to published estimates; population, ageing and autonomous improvement project the Reactive drift path.	STEP 2 Scenarios Four futures differ in start date, integration and financing; each sets an effort curve for every pathway.	STEP 3 Pathway effects $\text{Deaths} = \text{baseline} \times (1 - \text{ceiling} \times \text{effort})$. Climate uses a hazard $\times$ vulnerability form.	STEP 4 Interconnection Overlap discounts, interaction discount and cascade-sensitive shock module remove double counting.	STEP 5 Outcomes & uncertainty Deaths, DALYs, deprivation, resilience, cost; 5,000 joint draws; distribution by region, income and age.
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Four scenarios

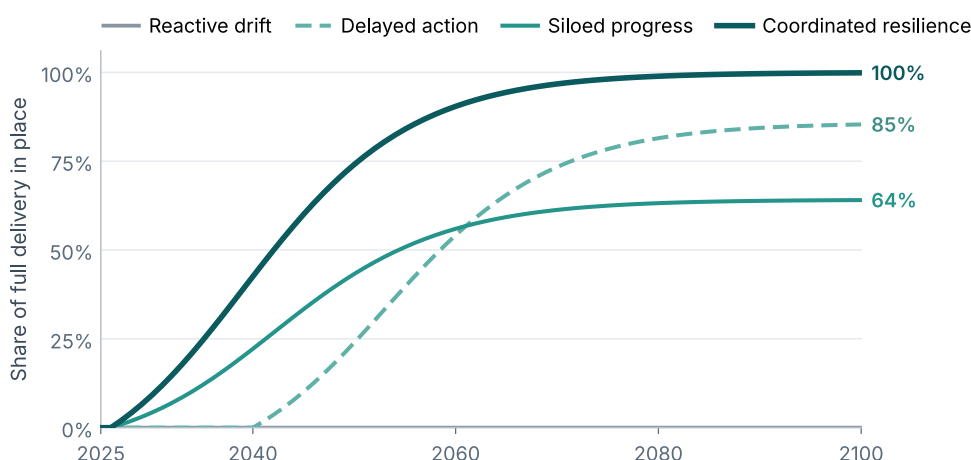
All benefits are measured against **Reactive drift**, a world that continues recent trends, including the slowing of progress on child and maternal mortality, the current policy trajectory for emissions and the contraction in development assistance. It is not stagnation: baseline deaths per person keep falling, but too slowly to meet existing global goals.

TABLE 3 Scenario definitions

Scenario	Action begins	Integration	Peak financing	Description
 S0 Reactive drift	No new action	None	Current	Current trends. Warming reaches 2.8°C by 2100 on current policies.
 S1 Delayed action	2040	High	1.25× S3 cost	Full programme begins 14 years late; lock-in and irreversible damage reduce ceilings by 10–20%; catch-up costs are higher.
 S2 Siloed progress	2026	Low	About 65% of S3	Sector ministries push ahead separately. Strong where delivery channels exist (health, water, energy), weak where integration is needed (food systems, adaptation, preparedness).
 S3 Coordinated resilience	2026	High	\$1.2T a year	Early, integrated, financed programme across all six pathways, with warming stabilising near 1.85°C in 2100.

FIGURE 3 Scenarios differ in when action starts and how much of it is delivered

Average share of full delivery in place across the six pathways



Source: H Heuristics HH-PRM v1.0. Effort curves are logistic ramps; see Appendix A.

Six mortality pathways

Each pathway starts from a published 2025 anchor and evolves under Reactive drift with population growth, ageing and an autonomous rate of improvement. A scenario then removes a share of those attributable deaths that rises along a logistic curve to a ceiling. Four pathways use this generic form:

GENERIC PATHWAY

$$D_{s,m}(t) = B_m(t) \times [1 - \rho_m \cdot \theta \cdot e_{s,m}(t)]$$

$$B_m(t) = B_{m,2025} \cdot (pop(t))^a \cdot (age(t))^b \cdot \exp(-d_m(t - 2025))$$

Here ρ is the pathway's ceiling, θ a delivery factor shared by all pathways and e the scenario's effort curve. The **climate pathway** multiplies hazard by vulnerability, so that mitigation and adaptation compose rather than add: deaths = $D_0 \times \text{population} \times \text{ageing} \times \exp(\beta \times \text{warming}) \times \text{vulnerability}$. The **shock pathway** is an expected-value model of pandemics and compound humanitarian crises, cross-checked against a stochastic simulation (Chapter 7).

Avoiding double counting

A child saved from diarrhoea might be counted under water and sanitation, nutrition and health systems at once. The model prevents this in three ways. First, pathways are defined as **distinct attributable burdens** where possible. Second, a pathway-specific **overlap discount** removes the share of deaths averted that other pathways also claim. Third, a global **interaction discount** of 0.92 reflects that interventions delivered together rarely deliver each one's theoretical maximum.

TABLE 4 Overlap discounts by pathway

Pathway	Overlap ω	Main source of overlap
Clean energy and air quality	8%	Household smoke deaths among children also claimed by health systems
Water, sanitation and hygiene	18%	Diarrhoeal deaths also counted as amenable to health care and as nutrition-related
Food and nutrition	22%	Undernutrition is an underlying cause in many infectious deaths
Health systems	25%	Largest overlap: amenable deaths include conditions averted by the other pathways
Climate	5%	Heat deaths among people with chronic disease
Shocks and pandemics	8%	Excess deaths during shocks partly reflect weak baseline health systems

Central values; the Monte Carlo scales all overlap discounts by a factor between 0.5 and 2.0.

Uncertainty

Uncertainty is propagated by **5,000 joint Monte Carlo draws** of 28 uncertain parameters: pathway ceilings, ramp timing, baseline burdens, autonomous improvement, climate sensitivity, adaptation ceilings, pandemic rates, overlap, interaction, demography, the 2100 warming of Coordinated resilience and valuation parameters. Crucially, all ceilings share a common **delivery factor** (0.7 to 1.2). Without it independent draws would average out and understate the real risk that delivery capacity falls short everywhere at once. One-at-a-time sensitivity and six stress tests are reported in Chapter 15.

Evidence grading

Parameters are graded in Appendix A: **Anchored** where tied directly to a published estimate, **Calibrated** where the form is ours but the magnitude is checked against published results, and **Judgement** where H Heuristics has set a value that the literature does not pin down, notably the ceilings and timing of each pathway. Readers who disagree with a judgement can reproduce any result from the appendix.

CHAPTER 4

The baseline: what is at stake without new action

About 21 million deaths a year are attributable to the six pathways in this report. Under reactive drift the burden barely falls for two decades.

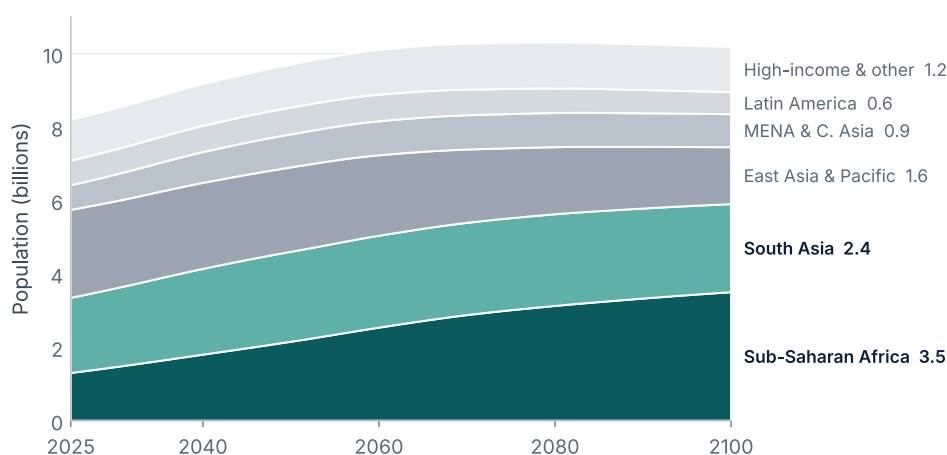
The baseline establishes what Reactive drift looks like in people. It draws on the most recent published burden estimates, which refer to different years, and projects them forward with demography and a modest rate of autonomous improvement. Observed deaths are distinguished from modelled deaths attributable to specific risks: nearly every figure here is of the second kind, and risk-attributable deaths are not additive across risks because one death can have several causes.

A growing and ageing world, growing fastest where vulnerability is highest

The UN's 2024 projections put world population at 8.2 billion in 2024, peaking near 10.3 billion in the mid-2080s and easing to about 10.2 billion by 2100, some 700 million fewer than projected a decade earlier.²⁴ Life expectancy has recovered from the pandemic dip to 73.3 years. Both facts matter for this report. A plateauing population limits the growth in absolute burden, while ageing raises it: by the late 2070s the number of people aged 65 and over is projected to exceed the number of children. Sub-Saharan Africa is the exception to demographic slowdown, growing from about 1.3 to about 3.5 billion in the model's rounded approximation of the UN medium variant.

FIGURE 4 Population growth after 2050 is concentrated in Sub-Saharan Africa and South Asia

World population by region, billions; labels show 2100 values



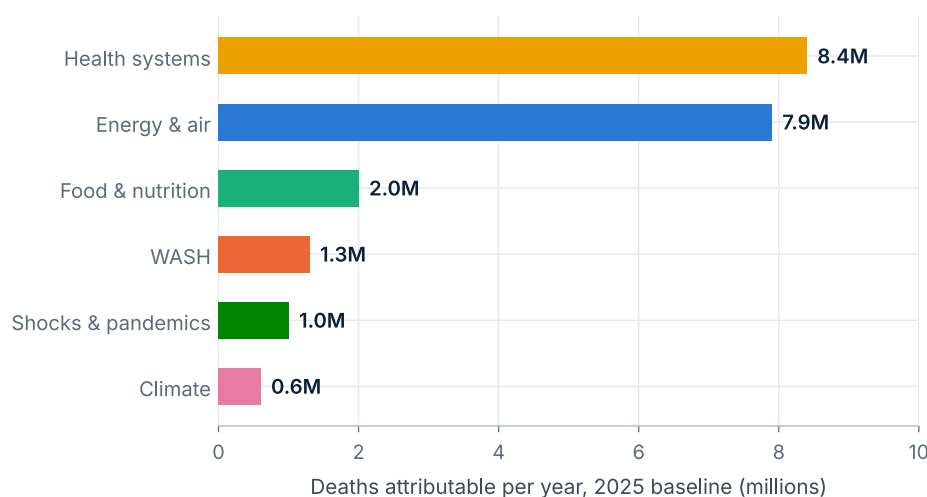
Source: H Heuristics rounded approximation of UN World Population Prospects 2024, medium variant (regional aggregates differ slightly from UN groupings).

The baseline burden

Figure 5 sets out the 2025 baseline for the six pathways. Two are dominated by non-communicable and older-age disease: air pollution, with 7.9 million deaths in 2023, and the health-system pathway, which draws on the Lancet Commission on High Quality Health Systems estimate that 8.6 million deaths a year in low- and middle-income countries in 2016 were amenable to health care, 5.0 million due to poor quality care and 3.6 million to non-use of services.^{5,30} The others are concentrated among children (water, nutrition) or intermittent (shocks).

FIGURE 5 Air pollution and amenable health deaths dominate the baseline burden

Attributable deaths per year in 2025, millions; pathways overlap and should not be summed as unique deaths



Source: HEI (2025); Kruk et al. (2018) trend-adjusted; WHO (2023); Lancet Countdown (2025); H Heuristics synthesis for nutrition and expected shock mortality. See Table 5 and Appendix A.

TABLE 5 Baseline anchors used in the model

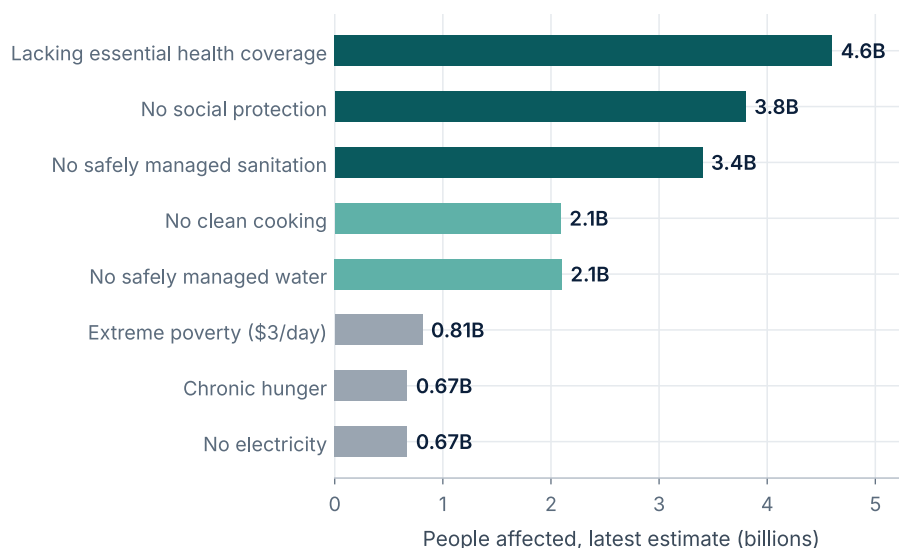
Indicator	Value	Source and note
Air-pollution deaths, 2023	7.9 million	HEI State of Global Air 2025; revises the 2021 estimate from 8.1 to 7.6 million after method changes ⁵
Under-5 deaths, 2024	4.9 million	UN IGME; 2.3 million are newborns; 58% in Sub-Saharan Africa, 25% in Southern Asia ⁶
Maternal deaths, 2023	260,000	About 70% in Sub-Saharan Africa ³⁷
Deaths from unsafe WASH, 2019	1.4 million	Including 395,000 children under five; WHO says the true burden is higher ³⁴
Heat-related deaths, 2012–21 average	546,000 a year	Lancet Countdown 2025 ⁸
COVID-19 excess deaths, 2020–21	14.9 million	Range 13.3 to 16.6 million ³⁵
Antimicrobial-resistance deaths, 2021	1.14 million	Directly attributable; forecast 1.91 million in 2050 ³³
Global DALYs, 2023	2.80 billion	Of which 1.27 billion attributable to 88 risk factors ²⁶

Deprivation: the stock of unmet need

Beyond deaths, the baseline records how many people lack the services that make resilience possible. Four and a half billion people lack full coverage of essential health services, 3.8 billion have no social protection, 3.4 billion lack safely managed sanitation, and 2.1 billion lack clean cooking and safely managed water.^{7,9,10,28} Around 0.8 billion live in extreme poverty on the World Bank's new US\$3.00 line, 673 million are chronically hungry and 666 million lack electricity, 85% of them in Sub-Saharan Africa.^{9,11,27}

FIGURE 6 Billions of people lack the services that underpin resilience

People affected by each deprivation, latest estimate, billions; indicators overlap strongly



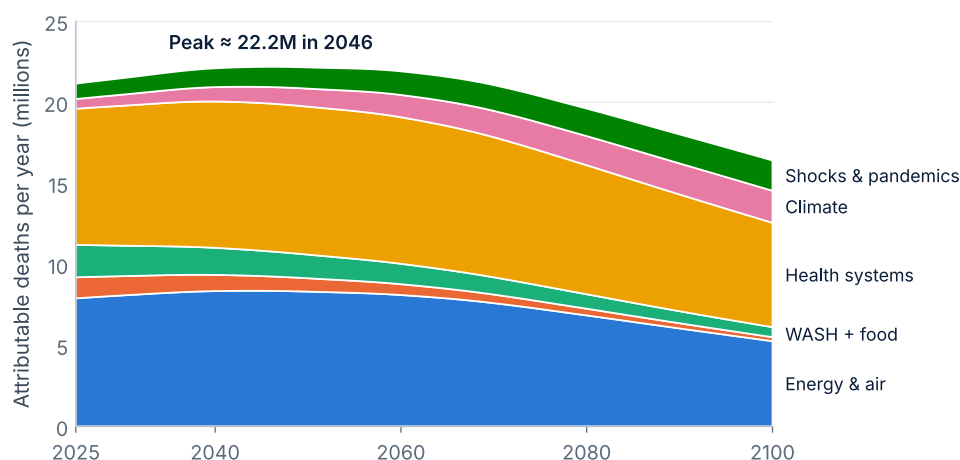
Source: WHO and World Bank (2025); ILO (2024); WHO/UNICEF JMP (2025); IEA et al. SDG7 (2025); World Bank (2025); FAO et al. (2025). Poverty is a 2025 projection.

Reactive drift is not stasis, but it is not enough

Under Reactive drift deaths per person keep falling. Even so, the total attributable burden stays near 21 million a year through mid-century, peaking at about 22.2 million, because ageing and population growth offset autonomous improvement; it falls to about 16 million by 2100. Cumulatively, the six pathways account for about 1,565 million attributable deaths over 2025–2100 before de-duplication. Tracker reports are unambiguous that universal access to safe water, clean cooking and basic health services will not be reached by 2030, and the child-mortality decline has slowed by more than 60% since 2015.^{6,9,10}

FIGURE 7 Under reactive drift the attributable burden stays above 20 million a year until about 2070

Attributable deaths per year under Reactive drift, millions; pathways overlap



Source: H Heuristics HH-PRM v1.0. Climate shows total climate-related deaths, not only the increment due to warming.

WHY THE BASELINE MATTERS FOR THE ANSWER

Every result in this report is a difference from this baseline. If baseline progress were faster, there would be less left to save; if the 2025 aid contraction persists, more. Chapter 15 tests both. A model that assumed no autonomous progress would overstate the prize several-fold; the baseline therefore builds in autonomous improvement of between 0.6% and 2.5% a year in per-person risk, depending on the pathway.

CHAPTER 5

Clean energy and air quality

Cleaner air is the single largest source of lives saved in the model: about 132 million net, 36% of the total.

The evidence

Air pollution killed an estimated 7.9 million people in 2023, 86% of them through non-communicable disease, and India and China each recorded more than 2 million attributable deaths.⁵ A substantial share of this burden comes from household smoke; roughly 2.1 billion people still rely on polluting fuels for cooking, a number that has fallen from about 3.0 billion in 2010 but is no longer shrinking faster than population grows.⁹ Another 666 million people lack electricity, 85% of them in Sub-Saharan Africa.

Climate and air policy are the same policy for health purposes. Shindell and colleagues estimated that a pathway meeting the more ambitious Paris temperature goal, rather than the less ambitious one, would avoid roughly 153 million premature deaths from fine particles and ozone this century, with the largest gains in Asia and Africa.¹⁵ Global energy investment is expected to reach about US\$3.3 trillion in 2025, of which US\$2.2 trillion is clean, but investment in the emerging economies that hold most of the unserved population is lagging.²³

How the model treats it

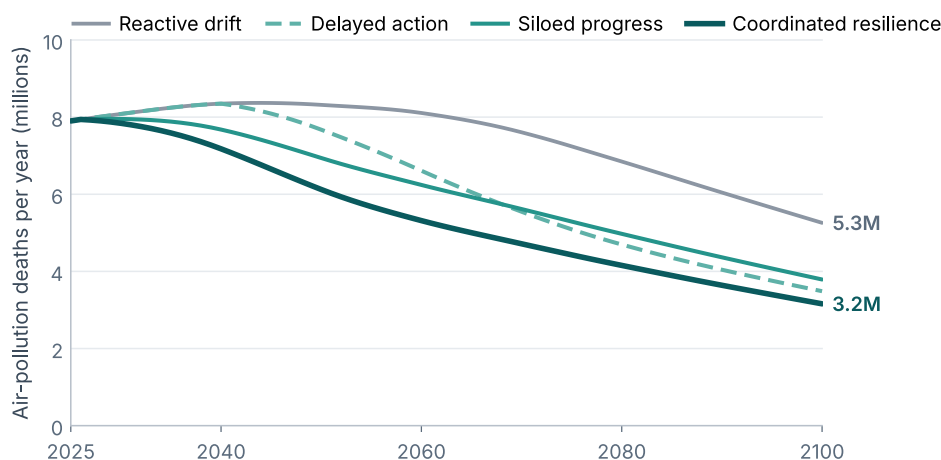
TABLE 6 Clean energy and air quality: key assumptions

Assumption	Value	Grade
2025 baseline attributable deaths	7.9 million a year	Anchored
Reactive drift trajectory	8.3 million in 2050; 5.3 million in 2100	Calibrated
Coordinated resilience ceiling	40% reduction relative to Reactive drift (interval 25–55%)	Judgement
Ramp midpoint	2042 (width 9 years)	Judgement
Overlap with other pathways	8%	Judgement

The ceiling is deliberately below what the physics allows. Pushing fine-particle exposure to the WHO guideline and universal clean cooking would remove well over half of attributable deaths, but a share of risk is non-modifiable by energy policy, and delivery is imperfect. A 40% ceiling means the world achieves, over two decades, roughly what the best-performing large regions achieved in recent decades, applied to the countries with the most to gain. The ramp is slow because clean cooking, grids and power plants turn over slowly.

FIGURE 8 Coordinated resilience cuts air-pollution deaths by 40% below the reactive path by the 2060s

Air-pollution deaths per year by scenario, millions



Source: H Heuristics HH-PRM v1.0.

What it takes

- **Clean cooking first.** It is the fastest and cheapest lever per life saved, and it also relieves the burden on women and children who collect fuel.
- **Electricity access in Sub-Saharan Africa** through a mix of grid and distributed solar, with an emphasis on health facilities, water pumping and cold chains.
- **Coal and diesel retirement in Asia** sequenced with grid investment and just-transition support so that air quality benefits are not delayed by energy-security concerns.
- **Monitoring.** Many low-income cities still lack a single reference-grade monitor; without data, targets cannot be enforced.

Results: under Coordinated resilience air-pollution deaths fall from 7.9 million to 6.1 million in 2050 and 3.2 million in 2100, against 8.3 and 5.3 million under Reactive drift. Net of overlap, the pathway averts 132 million deaths, 23% of the pathway's Reactive drift burden. Delaying action to 2040 cuts this to 79 million.

CHAPTER 6

Water, sanitation and food

Water and nutrition deliver the largest proportional cuts: 43% and 28% of their burdens, almost entirely among children.

Water, sanitation and hygiene

In 2019 unsafe water, sanitation and hygiene caused at least 1.4 million deaths and 74 million DALYs, including 395,000 deaths of children under five. Diarrhoea accounted for over a million deaths; WHO notes that only four health outcomes had usable data, so the true burden is likely higher.³⁴ More than three-quarters of these deaths occur in the WHO African and South-East Asia regions. The latest monitoring shows 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; coverage of safely managed water rose from 50% to 60% between 2015 and 2024, but universal coverage by 2030 now looks out of reach.¹⁰

Water is also the channel through which climate stress becomes a health crisis. Droughts shrink supply, floods contaminate it, and heat raises demand. Water security is therefore the clearest example of a pathway that pays twice: it lowers the baseline burden and reduces vulnerability to the climate shocks modelled in Chapter 8.

Food and nutrition security

An estimated 673 million people (8.2% of the world) were hungry in 2024, with a plausible range of 638 to 720 million. Hunger fell in Asia and Latin America but rose in Africa, where more than 20% of people, 307 million, were hungry.¹¹ The 2025 SOFI report projects 512 million still chronically undernourished in 2030, almost 60% of them in Africa, and 2.3 billion people, 28% of the world, were moderately or severely food insecure. For the first time the UN child-mortality estimates also counted deaths directly caused by severe malnutrition, which accounted for about 5% of deaths among children aged 1 to 59 months.⁶ Undernutrition's larger role is as an underlying risk that raises the lethality of infections.

TABLE 7 Water and nutrition: key assumptions

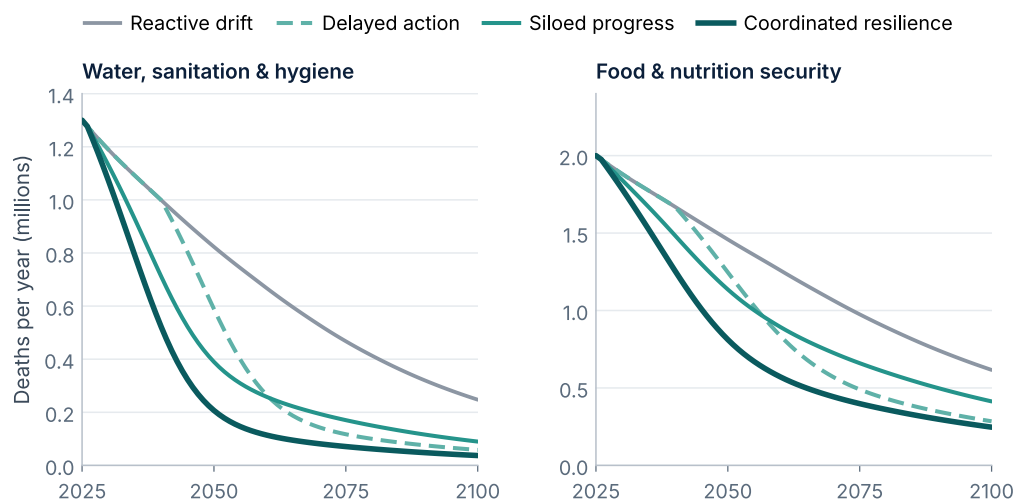
Assumption	Value	Grade
Water: 2025 baseline	1.3 million deaths a year (WHO 2019 figure trended down)	Anchored
Water: Reactive drift	0.82 million in 2050; 0.25 million in 2100	Calibrated
Water: ceiling and midpoint	85% reduction (interval 70–95%); midpoint 2037	Judgement
Nutrition: 2025 baseline	2.0 million attributable deaths a year	Judgement
Nutrition: Reactive drift	1.46 million in 2050; 0.62 million in 2100	Calibrated
Nutrition: ceiling and midpoint	60% reduction (interval 40–75%); midpoint 2040	Judgement

The nutrition baseline is the least well anchored in the model: there is no single published estimate of deaths attributable to undernutrition that is current and non-overlapping, so the figure of 2.0 million is an H Heuristics synthesis that treats undernutrition as an attributable cause for child and maternal deaths

after removing the overlap counted under water and health. It is graded as Judgement, and the 22% overlap discount for nutrition is the highest of any non-health pathway.

FIGURE 9 Water and nutrition deaths fall fastest under coordinated action

Attributable deaths per year by scenario, millions



Source: H Heuristics HH-PRM v1.0.

What the results show

Coordinated resilience cuts water-related deaths from 1.3 million to 0.21 million by 2050 against 0.82 million under Reactive drift, and nutrition-related deaths to 0.81 million against 1.46 million. Net of overlap the two pathways avert 22 and 26 million deaths respectively. They are small in absolute terms next to air and health because the baseline is smaller and because Reactive drift already assumes substantial autonomous progress. But they carry among the largest DALY loads per death, because the people saved are young: each death averted in these two pathways carries 53 and 84 DALYs, against 29 for air pollution (Chapter 11).

Siloed progress performs relatively well on water, which has strong sector delivery channels (the model credits it with 75% of the Coordinated ceiling), and relatively poorly on food systems, where progress requires agriculture, trade, social protection and health to act together (55%).

What it takes

- **Universal safely managed water and sanitation by the mid-2040s**, prioritising rural Sub-Saharan Africa and South Asia, where deaths concentrate.
- **Nutrition in the first 1,000 days**, community management of wasting, and fortification, delivered through primary care.
- **Climate-resilient food systems**: seed, storage, irrigation and early warning for drought and price shocks.
- **Shock-responsive social protection** so that a harvest failure triggers cash and food within days, not months.

CHAPTER 7

Health systems, infectious disease and pandemics

Quality health systems carry 27% of lives saved; preparedness for pandemics and compound shocks adds 42 million more.

Health systems

The Lancet Commission on High Quality Health Systems estimated that 15.6 million deaths in 2016 in low- and middle-income countries from 61 conditions were excess deaths, of which 8.6 million were amenable to health care: 5.0 million due to poor quality of care and 3.6 million due to non-use of services.³⁰ Its conclusion, that coverage expansion without quality does not save lives, shapes the model. The 2025 WHO and World Bank monitoring report finds that 4.6 billion people still lack essential health services and 2.1 billion face financial hardship in accessing care, including 1.6 billion pushed into or deeper into poverty by health costs, even though the service coverage index rose from 54 to 71 between 2000 and 2023.⁷

Preventive investments with large track records point the same way. Global immunisation efforts are estimated to have saved at least 154 million lives in fifty years, 101 million of them infants, with measles vaccination alone accounting for 60%.³² Maternal deaths fell about 40% between 2000 and 2023, to around 260,000, but progress has slowed sharply since 2016, and 37 fragile countries account for 64% of the total.³⁷ The pace of decline in under-5 mortality has slowed by more than 60% since 2015.⁶

Antimicrobial resistance is the slow-moving threat inside the health system. Resistant bacterial infections directly caused 1.14 million deaths in 2021 and the forecast is for 39 million direct deaths between 2025 and 2050 without further intervention, with the highest burden in South Asia.³³ The model treats resistance as part of the health-system baseline and tests a surge in Chapter 15.

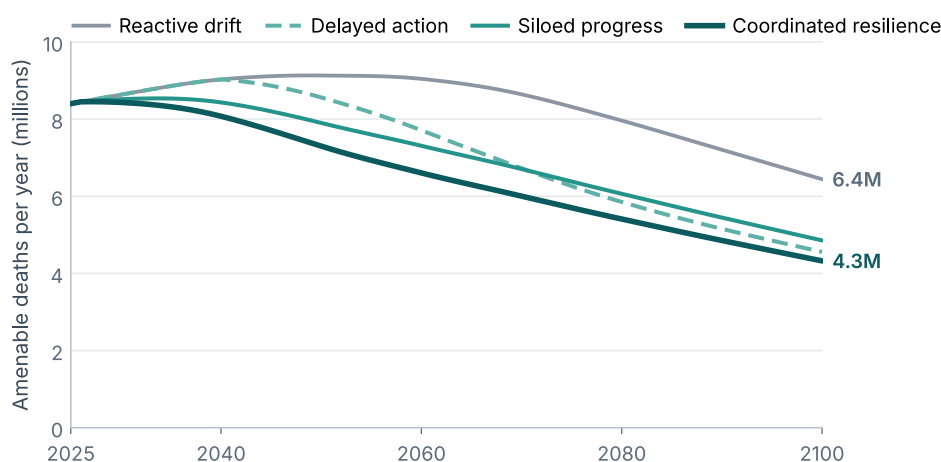
TABLE 8 Health systems: key assumptions

Assumption	Value	Grade
2025 baseline	8.4 million amenable deaths a year (Kruk et al. 2016 estimate trended down)	Anchored
Reactive drift	9.1 million in 2050; 6.4 million in 2100	Calibrated
Coordinated resilience ceiling	33% reduction (interval 20–48%)	Judgement
Ramp midpoint	2043 (width 10 years)	Judgement
Overlap	25%	Judgement

The ceiling is the most conservative among the generic pathways relative to the theoretical maximum. Kruk and colleagues argue that all 8.6 million amenable deaths are in principle avertable; the model assumes only a third relative to a baseline that already improves, because workforce, supply chains and quality take decades to build and because fragile settings absorb a large share of the burden.

FIGURE 10 Quality health systems cut amenable deaths by about a third relative to the reactive path

Amenable deaths per year by scenario, millions



Source: H Heuristics HH-PRM v1.0.

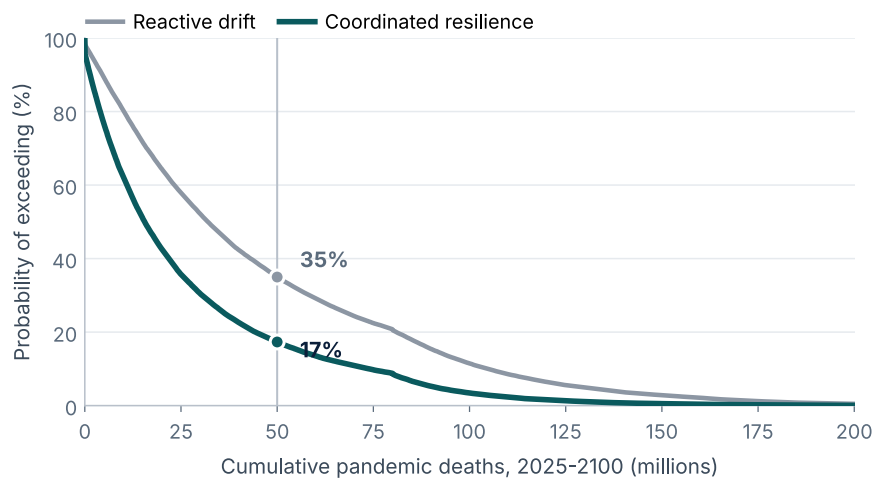
Pandemics and compound shocks

COVID-19 showed what a reactive world pays: 14.9 million excess deaths in 2020–21 (range 13.3 to 16.6 million), 81% of them in middle-income countries.³⁵ A properly financed preparedness system has been costed at roughly US\$31 billion a year by WHO and the World Bank and at least US\$34 billion by the G20 High Level Independent Panel, a small fraction of one pandemic's losses; the panel's 2026 report finds financing and implementation have lagged far behind need as donors retrench.³⁶

The shock pathway combines two components. **Pandemics** are modelled as a random process with a frequency of 4.5% a year, heavy-tailed severity (median 3.5 million deaths, capped at 80 million) and an expected annual toll of about 0.45 million deaths today. **Compound humanitarian crises**, famines and conflict-linked excess mortality, add a further expected 0.5 million deaths a year that rises with warming. Preparedness cuts pandemic frequency by up to 25% and severity by up to 40%; social protection and early action cut humanitarian mortality by up to 35%.

FIGURE 11 Preparedness halves the chance of a catastrophic pandemic century

Probability that cumulative pandemic deaths, 2025–2100, exceed a given level, per cent; 40,000 simulated centuries per scenario



Source: H Heuristics HH-PRM v1.0 stochastic pandemic simulation. Dots mark the probability of exceeding 50 million deaths.

The stochastic simulation makes the asymmetry concrete. Under Reactive drift there is a 35% chance that pandemics alone kill more than 50 million people this century, and a one-in-ten chance of more than 105 million. Under Coordinated resilience those fall to 17% and 74 million. The expected benefit of preparedness is a modest number; the reduction in the tail is the real prize, and one that averages hide.

CHAPTER 8

Climate adaptation and mitigation

Warming of 2.8°C versus 1.85°C changes more than the thermometer: it changes how many people die from heat and extremes, and how many can adapt.

What the evidence says

Heat-related deaths averaged about 546,000 a year in 2012–21, a 63% rise since the 1990s, and 2024 was the hottest year on record.⁸ Looking forward, the World Health Organization's earlier assessment put additional climate-driven deaths from undernutrition, malaria, diarrhoea and heat stress at about 250,000 a year in 2030–2050.¹⁷ Bressler's mortality cost of carbon estimated 83 million cumulative excess heat-related deaths between 2020 and 2100 under business-as-usual emissions, falling to about 9 million with full decarbonisation by 2050.¹⁴ Carleton and colleagues find that the mortality-temperature relationship is U-shaped and is flattened by higher incomes and adaptation, so that today's poor and hot places face the largest damages and some cold places benefit.¹⁶

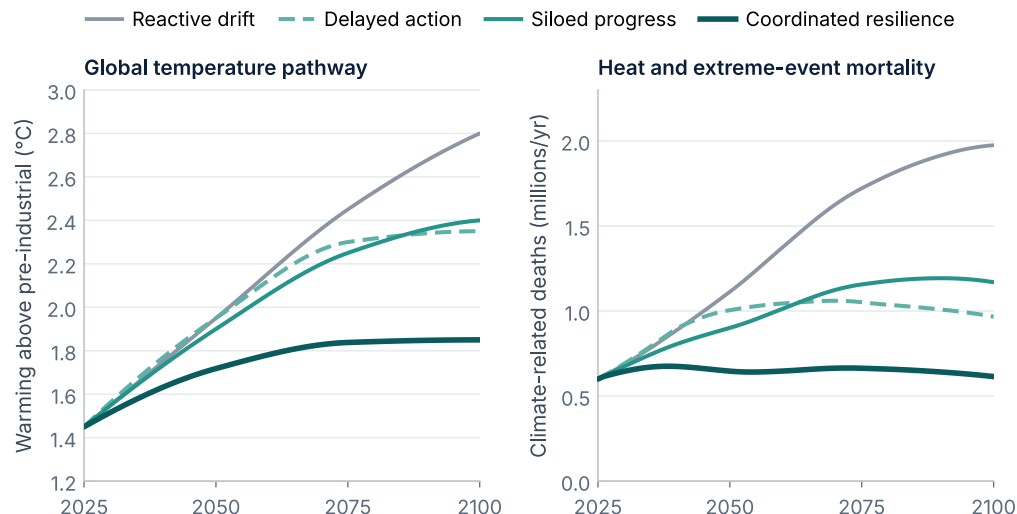
The temperature path itself is uncertain. UNEP's 2025 assessment projects 2.8°C of warming by 2100 on current policies and 2.3–2.5°C if all national pledges are fully implemented.¹³ Adaptation is chronically underfunded: international public adaptation finance to developing countries was US\$26 billion in 2023, against needs of US\$310 billion a year by 2035 on modelled costs and US\$365 billion by extrapolating national plans, 12 to 14 times current flows.¹²

Hazard times vulnerability

The climate pathway is the only one in the model with a physical hazard component. Annual climate-related deaths are the product of baseline deaths (0.6 million: heat plus extreme events), a population and ageing factor, a hazard factor that rises exponentially with warming (by 0.6 per °C in the central case, interval 0.35–0.90) and a vulnerability factor that falls with autonomous adaptation (0.6% a year) and, under coordinated scenarios, with proactive adaptation up to 45% (interval 30–60%).

FIGURE 12 Mitigation and adaptation each bend the climate-mortality curve

Left: global mean warming above pre-industrial, °C. Right: climate-related deaths per year, millions



Source: H Heuristics HH-PRM v1.0. Reactive drift warming anchored to UNEP (2025).

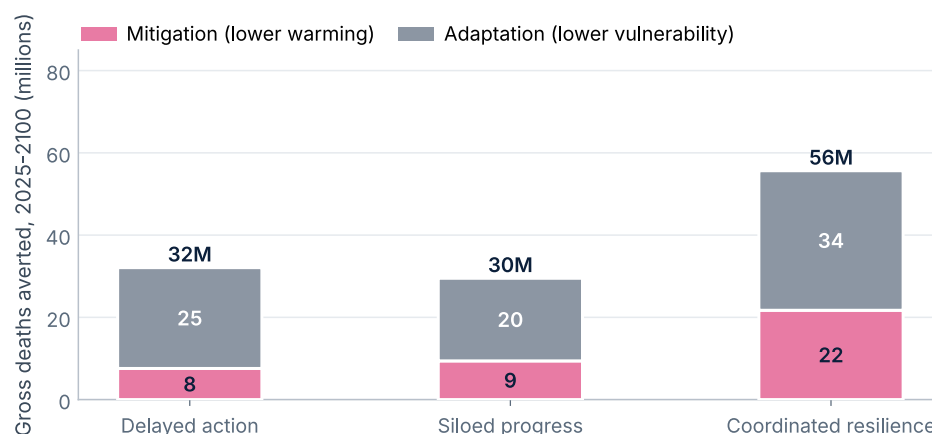
As a calibration check, the model's Reactive drift path implies annual climate-related deaths rising from 0.6 million today to 0.89 million in 2040, an increase of 0.29 million, consistent with the WHO estimate of about 0.25 million additional deaths a year in 2030–2050. By 2100 deaths under Reactive drift reach 2.0 million a year against 0.6 million under Coordinated resilience.

Mitigation versus adaptation

Because hazard and vulnerability multiply, the effect of one depends on the other. The model attributes gross deaths averted between them using an order-averaged (Shapley) decomposition. **Figure 13** shows that, for Coordinated resilience, adaptation accounts for about 34 million and mitigation about 22 million of the 56 million gross climate-related deaths averted.

FIGURE 13 Adaptation delivers more lives this century; mitigation protects the long term

Gross climate-related deaths averted, 2025–2100, millions, Shapley attribution



Source: H Heuristics HH-PRM v1.0.

Two cautions. First, the mitigation figure is a **lower bound on benefit**: this report counts mortality only through heat and extreme events, not the impacts of sea level, ecosystems, conflict or economic disruption, and not the continuing damage after 2100. Bressler's larger estimates reflect a much hotter baseline (about 4°C). Second, the split is a property of the 2100 horizon. A longer horizon would raise the mitigation share because warming-driven mortality continues to grow while adaptation saturates.

ADAPTATION IS HEALTH POLICY

Early warning, heat action plans, cooling, flood defences and shock-responsive social protection are rarely classified as health spending but save lives measurably. In the model, proactive adaptation alone averts about 34 million gross deaths and cuts the number of people in high-vulnerability contexts by 1.6 billion by 2050 (Chapter 12). The global financing gap for adaptation is the cheapest large gap to close in this report.

CHAPTER 9

Development convergence and the Global South

Sustainable development is the setting in which most lives are saved. It works through services, income and capacity, not through a separate line in the model.

Every pathway in this report is a development outcome. Clean cooking and electricity, safe water, nutrition, primary care and social protection are what development *is* for the poorest billions. The model therefore treats development convergence as an **enabling condition** that sets ceilings and timing for each pathway, and as a direct outcome through the deprivation ledger, rather than as a separate source of avoided deaths that would double count the others.

Why the Global South is the centre of gravity

- **Mortality:** Sub-Saharan Africa and Southern Asia account for 83% of under-5 deaths and the large majority of maternal, WASH and nutrition deaths.^{6,37}
- **Exposure:** 89% of the 1.81 billion people exposed to 1-in-100-year floods live in low- and middle-income countries.²⁰
- **Infrastructure gap:** 85% of people without electricity live in Sub-Saharan Africa, where population will nearly triple by 2100.^{9,24}
- **Finance:** an expert group estimated that emerging and developing countries other than China need to raise climate and development investment to about US\$2.4 trillion a year by 2030, with about US\$1 trillion a year from external sources, against falling aid.^{3,22}

Income, technology and convergence

Three mechanisms link development to resilience. **Income** flattens the mortality-temperature curve and raises the ability to pay for cooling, care and insurance.¹⁶ **Technology diffusion** allows low-income countries to leapfrog: distributed solar and mobile money reach places grids and banks do not, and the global pool of clean energy investment, now US\$2.2 trillion a year, creates manufacturing scale that lowers costs for everyone.²³ **Capacity and institutions** convert money into outcomes: the model's delivery factor, which drives more of the uncertainty than any scientific parameter, is a proxy for them.

Burden-of-disease forecasts already build in some convergence, with low-life-expectancy regions expected to gain most by 2050; the question is whether it is fast enough.²⁵

Deprivation under each scenario

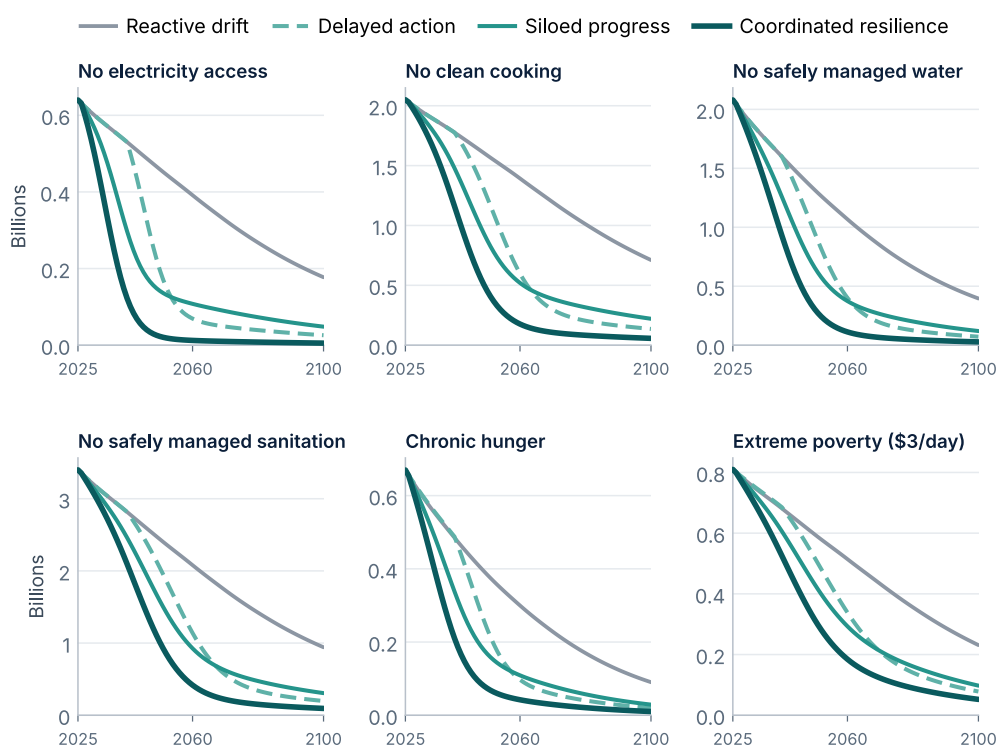
TABLE 9 Closing the gaps: people deprived of each service, billions

Service gap	2025	2050 reactive drift	2050 coordinated	Gain by 2030	Gain by 2050
No electricity access	0.64	0.46	0.02	0.10	0.44
No clean cooking	2.05	1.59	0.45	0.10	1.13
No safely managed water	2.08	1.32	0.31	0.14	1.01
No safely managed sanitation	3.40	2.44	1.01	0.13	1.43
Chronic hunger	0.67	0.38	0.07	0.07	0.31
Extreme poverty (\$3/day)	0.81	0.60	0.32	0.04	0.28
Lacking essential health coverage	4.60	3.74	1.79	0.24	1.95
No social protection	3.80	2.59	1.15	0.20	1.44

Gains are people with access under Coordinated resilience minus Reactive drift. Services overlap; do not sum the rows.

FIGURE 14 Every service gap closes faster under coordinated action, with the largest differences before 2060

People lacking each service by scenario, billions



Source: H Heuristics HH-PRM v1.0. Climate-sensitive services (hunger, poverty) include a warming penalty.

The table and figure show two features. **Gains are large relative to baseline progress:** by 2050 Coordinated resilience brings 1.4 billion additional people to safely managed sanitation and 1.1 billion to clean cooking beyond what Reactive drift delivers. And **gains by 2030 are small** (a quarter of a billion people lacking at least one service), because ramps take time. Universal access by 2030 is not credible on these numbers; universality by 2040 to 2050 is, if effort starts now.

CHAPTER 10

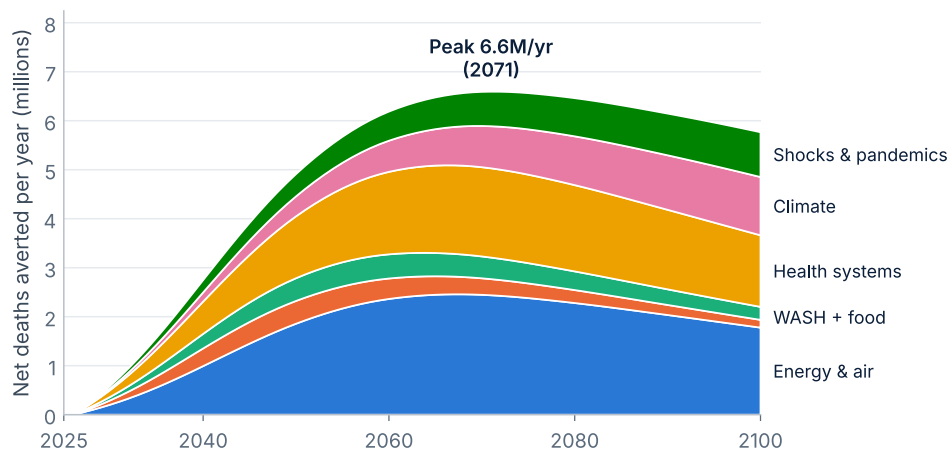
Lives saved

Under coordinated resilience about 368 million deaths are averted between 2025 and 2100, a 90% interval of 265–448 million.

The headline is a cumulative figure, but its shape is as informative as its size. In the first five years almost nothing happens: 1.4 million lives are saved by 2030. By 2040 the cumulative total is 19 million and by 2050 it is 58 million. The great majority arrive later: 213 million by 2075 and 368 million by 2100. Annual lives saved peak at 6.6 million around 2071, as ramps mature while the underlying burden is still high. Averaged across the century that is about 13,263 lives a day.

FIGURE 15 Annual lives saved peak at 6.6 million around 2071

Net deaths averted per year under Coordinated resilience, by pathway, millions



Source: H Heuristics HH-PRM v1.0. Net of overlap and interaction discounts.

Where the lives come from

TABLE 10 Deaths averted by pathway under Coordinated resilience, 2025–2100, millions

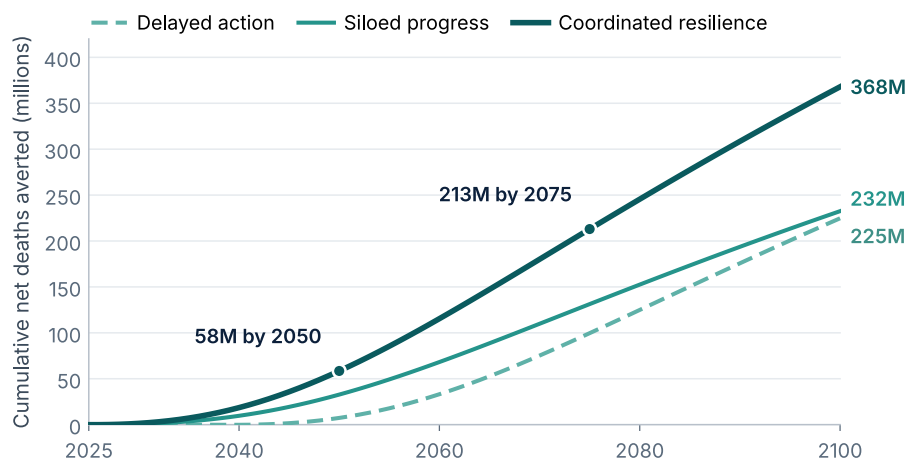
Pathway	Reactive drift burden	Gross averted	Net averted	Share of net	Net as % of burden
■ Clean energy & air quality	567	155	132	36%	23%
■ Water, sanitation & hygiene	52	29	22	6%	43%
■ Food & nutrition security	94	36	26	7%	28%
■ Health systems & infectious disease	637	141	98	27%	15%
■ Climate adaptation & mitigation	105	56	49	13%	46%
■ Pandemic & compound-shock preparedness	111	49	42	11%	38%
All pathways	1,565	468	368	100%	24%

Reactive drift burden is attributable deaths summed over 2025–2100 before de-duplication across pathways. Net averted removes overlap and the interaction discount.

Clean energy and air quality, and health systems, together provide 62% of lives saved because they act on the two largest burdens. The pathways with the highest proportional impact are water (43% of burden averted) and climate (46%), the latter because it combines two multiplicative levers. Pathways with the largest baseline burdens deliver modest percentages, but small percentages of enormous numbers.

FIGURE 16 Coordinated resilience pulls away from the alternatives after 2050

Cumulative net deaths averted relative to Reactive drift, millions



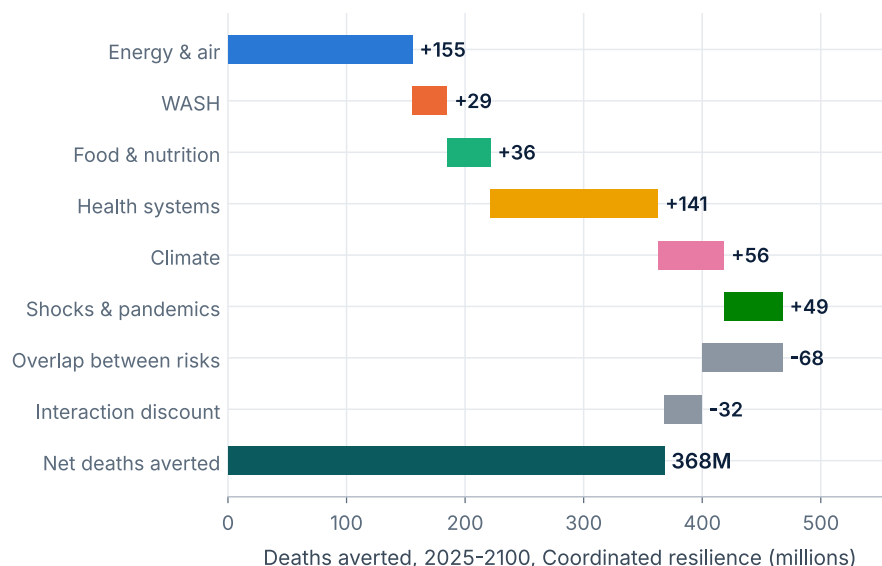
Source: H Heuristics HH-PRM v1.0.

From gross to net

Adding up pathway-by-pathway estimates gives 468 million gross deaths averted. The model removes 68 million for overlap between pathways and a further 32 million through the interaction discount, leaving 368 million net. About 21% of the naive total is thus discounted away, a haircut that reflects the central principle of this report: benefits are not to be counted twice.

FIGURE 17 About 21% of the gross total is removed as overlap and interaction

Bridge from gross deaths averted by pathway to net deaths averted, Coordinated resilience, 2025–2100, millions



Source: H Heuristics HH-PRM v1.0.

Comparing the four futures

TABLE 11 Results by scenario, 2025–2100

Scenario	Net deaths averted (M)	90% interval (M)	By 2050 (M)	Healthy life-years (B DALYs)
S1 Delayed action	225	159–275	7	8.4
S2 Siloed progress	232	165–284	33	8.8
S3 Coordinated resilience	368	265–448	58	13.6

Intervals are 5th–95th percentiles of 5,000 joint Monte Carlo draws. Reactive drift is the zero point.

Two comparisons stand out. First, **Delayed action and Siloed progress deliver almost the same lives over the century** (225 and 232 million) for very different reasons. Delay delivers late and loses the early decades entirely: by 2050 it has averted only 7 million lives against 33 million for the siloed path. Silos deliver early but never reach the integrated ceiling. Second, the two failure modes are **additive in their harm**: a world that is both late and fragmented would do worse than either, and Chapter 15 shows what partial delivery implies.

SANITY CHECK AGAINST THE LITERATURE

The model's 155 million gross deaths averted in clean energy and air quality is the same order as the 153 million premature deaths from air pollution that Shindell et al. attributed to the more ambitious temperature pathway, though the scope differs (ours includes household air pollution and a different baseline).¹⁵ The climate pathway's 56 million lies between Bressler's 9 million (decarbonised) and 83 million (business as usual) heat-death totals, as it should for a 2.8°C baseline and 1.85°C alternative.¹⁴ The total of 368 million is about 24% of the 1,565 million attributable deaths under Reactive drift (before de-duplication), and some 26 times the 14 million deaths projected from recent aid cuts by 2030.⁴

CHAPTER 11

Healthy life-years gained

The same deaths averted carry very different amounts of healthy life. The 368 million lives saved bring 13.6 billion DALYs.

A death at age two forfeits about 80 years of life; a death at 80 forfeits perhaps six. A report that counted only deaths would treat them alike. The DALY, which combines years of life lost with years lived in less than full health, corrects for this. The model converts deaths averted into DALYs using a pathway-specific number of life-years lost per death and an uplift for non-fatal illness averted alongside.

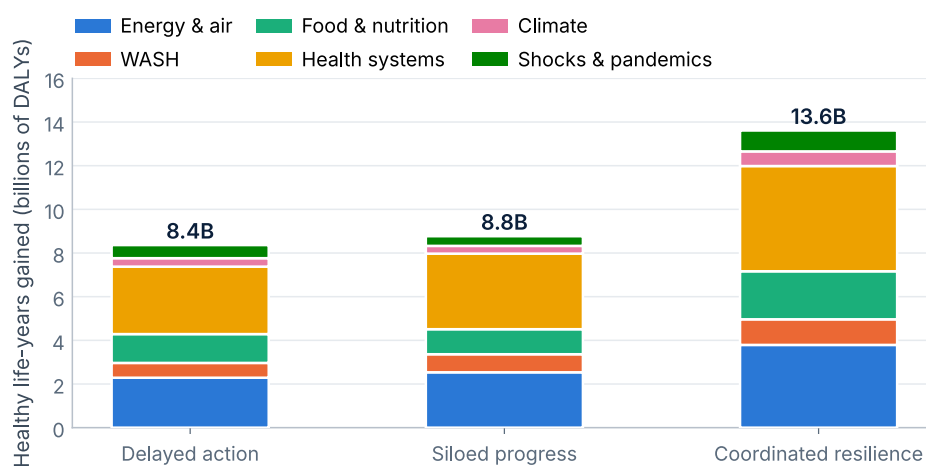
TABLE 12 DALYs per death averted and totals under Coordinated resilience

Pathway	Years of life lost per death	Non-fatal uplift	DALYs per death	DALYs averted (B)	Discounted at 3% (B)
Energy & air	24	+20%	29	3.79	1.16
WASH	48	+10%	53	1.17	0.45
Food & nutrition	58	+45%	84	2.20	0.76
Health systems	38	+30%	49	4.82	1.43
Climate	12	+15%	14	0.67	0.17
Shocks & pandemics	17	+35%	23	0.96	0.26
All pathways			37	13.6	4.2

Parameters are H Heuristics calibrations to published age profiles; the water figure matches the WHO ratio of 74 million DALYs to 1.4 million deaths in 2019 (53 per death).

FIGURE 18 Coordinated resilience gains 13.6 billion healthy life-years

Healthy life-years gained (DALYs averted) by scenario and pathway, billions, undiscounted



Source: H Heuristics HH-PRM v1.0.

What the billions mean

The global burden of disease was about 2.8 billion DALYs in 2023.²⁶ Averaged across 76 years, the 13.6 billion DALYs averted equal 179 million a year, or about 6% of today's annual burden. That may sound modest; it is the equivalent of removing an entire year's global disease burden every 16 years, in perpetuity, by one coordinated programme.

Three features of the DALY ledger are worth noting.

- **Health systems and air quality dominate again**, with 4.8 and 3.8 billion DALYs, but **nutrition punches above its weight**: it accounts for 7% of deaths averted and 16% of DALYs, because it protects the very young.
- **Climate is the opposite**: 13% of lives but only 5% of healthy life-years, because heat mortality is concentrated among older adults. This is a reason to value adaptation for other benefits, not a reason to discount it.
- **Discounting at 3%** reduces the total to 4.2 billion because much of the benefit lies in the second half of the century. The monetised comparison in Chapter 14 uses the discounted figure.

CHAPTER 12

Lives improved: deprivation and resilience

Many of the largest gains are not deaths averted. They are people who gain light, clean air, water, food and protection, and who are less likely to be ruined by the next shock.

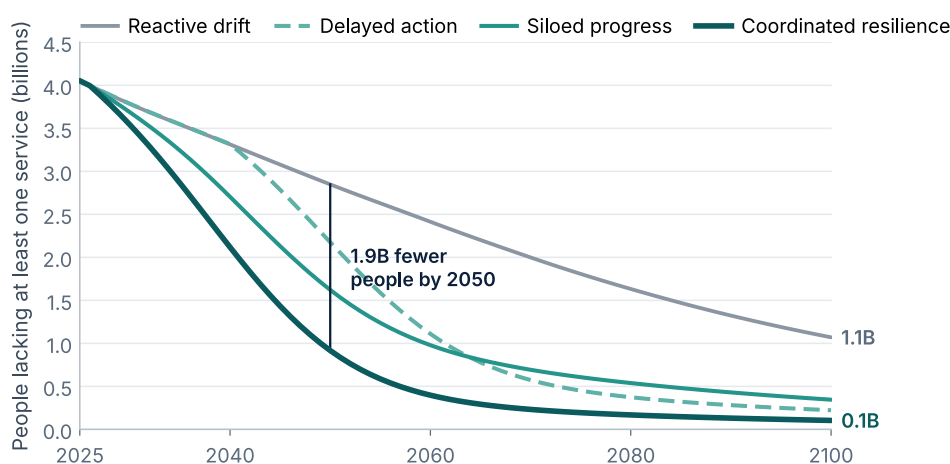
This chapter reports the third and fourth ledgers. They answer a different question from the first two: not “who survives?” but “who lives with a materially better chance at a decent life?” Two principles apply. People are counted only when they *gain* a service they lacked, and the two ledgers are never added to deaths averted.

Severe deprivation reduced

The model tracks six basic services: electricity, clean cooking, safely managed water, safely managed sanitation, food security and income above the extreme-poverty line. Summing the shortfalls would count the same person several times, because deprivations cluster, so the model also reports **unique persons lacking at least one**, estimated by applying an overlap factor of 0.42 to the sum of the six shortfalls (about 4.1 billion people in 2025).

FIGURE 19 By 2050 coordinated resilience leaves 0.9 billion people deprived, against 2.8 billion otherwise

People lacking at least one of six essential services, billions, by scenario



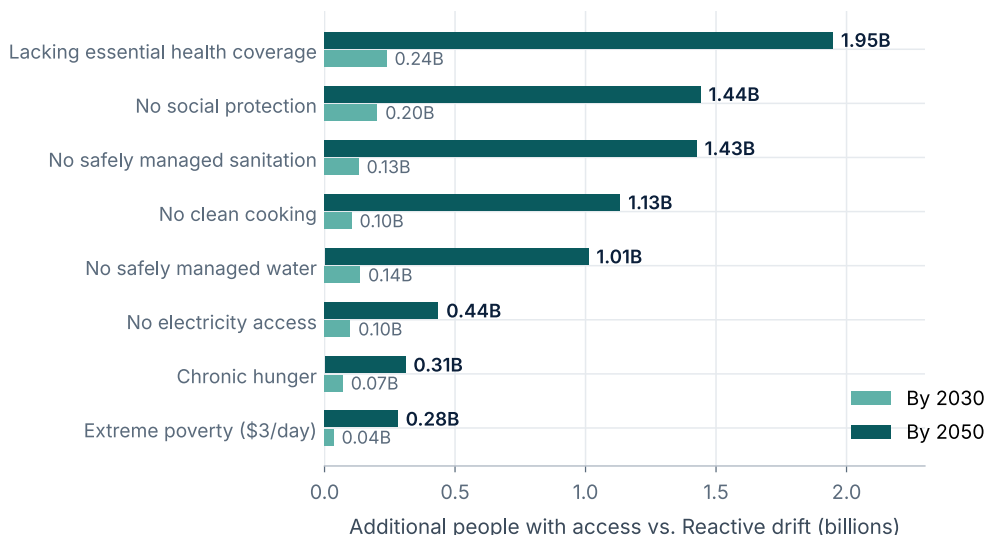
Source: H Heuristics HH-PRM v1.0. Unique persons estimated with an overlap factor of 0.42 (see Appendix A).

Under Reactive drift the number of people lacking at least one of the six services falls from 4.1 billion in 2025 to 2.8 billion in 2050 and 1.1 billion in 2100. Under Coordinated resilience it falls to 0.9 billion in 2050 and about 0.1 billion in 2100. The difference, 1.9 billion people in 2050 (interval 1.4–2.2 billion), is the

lives-improved headline. Over the whole century it equals about 103 billion person-years of severe deprivation avoided.

FIGURE 20 Sanitation, clean cooking, health coverage and water account for the largest gains

Additional people with access under Coordinated resilience relative to Reactive drift, by 2030 and 2050, billions



Source: H Heuristics HH-PRM v1.0. Essential health coverage and social protection are reported separately and are not in the six-service composite.

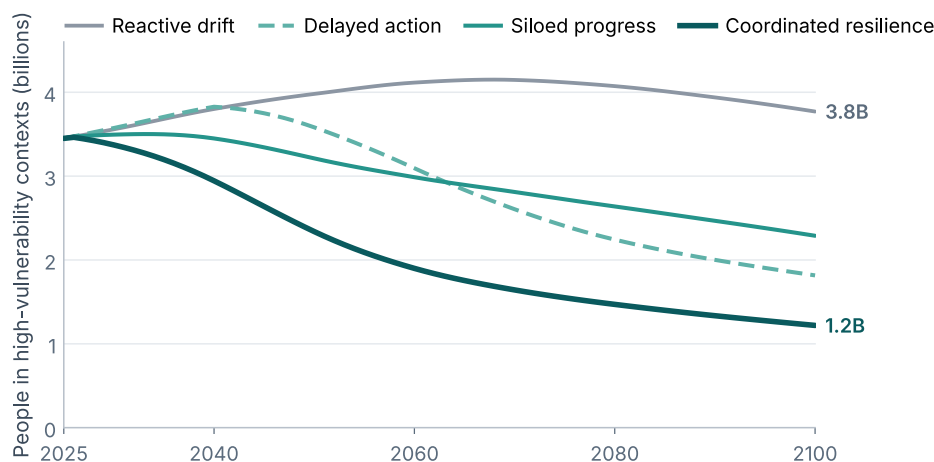
The gain by 2030 is small, only 0.2 billion people, and arrives mostly in the second half of the 2030s. Health coverage and social protection add large numbers: 1.9 billion more people with essential health coverage and 1.4 billion more with some social protection by 2050, relative to Reactive drift.

Resilience improved

The IPCC assessed that 3.3 to 3.6 billion people live in contexts that are highly vulnerable to climate change.²⁹ The model sets the 2025 level at 3.45 billion, lets it evolve with income, climate exposure and ageing, and applies a reduction under coordinated scenarios that stands for adaptation, early warning, shock-responsive social protection and heat and flood protection. The measure is the number of people whose vulnerability falls, not the number whose hazard changes.

FIGURE 21 Without action the highly vulnerable population grows to about 4 billion; with action it halves

People in high-vulnerability contexts, billions, by scenario



Source: H Heuristics HH-PRM v1.0. Baseline 3.45 billion in 2025 (IPCC AR6 range 3.3–3.6 billion).

Under Reactive drift the highly vulnerable population rises from 3.45 billion to 4.0 billion in 2050, because warming and ageing outrun income growth, and remains near 3.8 billion in 2100. Under Coordinated resilience it falls to 2.3 billion in 2050 and 1.2 billion in 2100. By 2050 the number of people with materially lower vulnerability is 1.6 billion (interval 1.2–1.8 billion). Delayed action leaves 3.6 billion in 2050 vulnerable, nearly no improvement for 25 years. Siloed progress leaves 3.2 billion.

WHY THE RESILIENCE LEDGER IS SEPARATE

A heat action plan that prevents a hundred deaths in a city is a lives-saved result. The same plan also protects every resident who might have been harmed or impoverished. The second benefit is real, valued by communities and central to adaptation policy, but it is a different quantity and cannot be monetised or compared with deaths without further assumptions. The report counts it separately and states it only as people.

CHAPTER 13

Who benefits: region, income and generation

Eighty-nine per cent of the benefit goes to the Global South, and most of the lives saved belong to people who are children today or not yet born.

The model allocates each pathway's net deaths averted to regions using that pathway's baseline distribution (for example, the 58% of under-5 deaths in Sub-Saharan Africa), evolving with each region's population, with a modest regional delivery weight that reflects capacity constraints (0.90 for Sub-Saharan Africa, 1.00–1.05 elsewhere). Region shares are working assumptions informed by the published distributions in Chapters 4–8 and are tabulated in Appendix B.

Regions

FIGURE 22 Sub-Saharan Africa and South Asia receive three-fifths of the lives saved

Net deaths averted under Coordinated resilience by region, 2025–2100, millions (left) and per 1,000 people alive in 2025 (right)



Source: H Heuristics HH-PRM v1.0. Regional allocation weights are working assumptions (Appendix B).

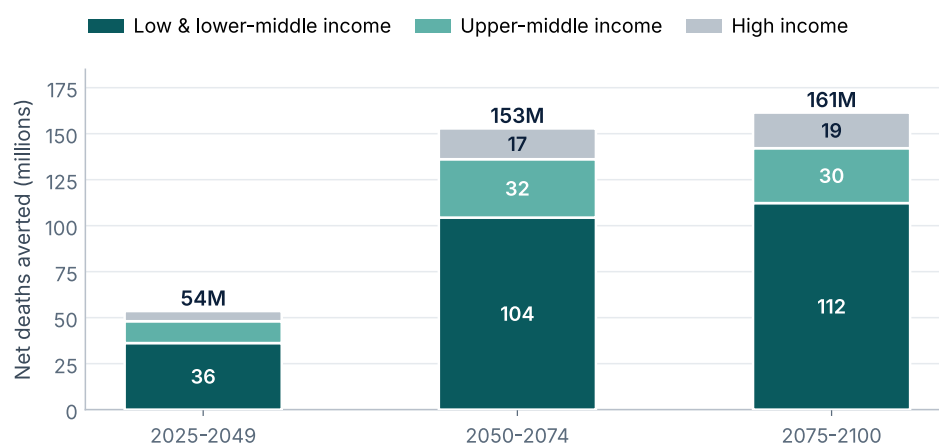
Sub-Saharan Africa gains 118 million lives and South Asia 111 million, together 62% of the total. Per head the contrast is sharper: about 91 lives saved per 1,000 people alive in Sub-Saharan Africa in 2025, 54 in South Asia and 25 in East Asia and Pacific. High-income countries gain 31 million, mostly from heat adaptation, pandemic preparedness and the air-quality co-benefits of decarbonisation. The distribution makes a practical point: **most of the global public good is delivered in places that cannot finance it alone.**

Income groups

Mapping regions to World Bank income groups, low- and lower-middle-income countries receive 253 million lives (69%), upper-middle-income countries 73 million (20%) and high-income countries 42 million (11%). Income-group shares are held constant, which is conservative: as countries graduate to higher income groups, today's low-income burden will increasingly be counted as middle-income. The proportion in the Global South as a whole (89%) is the more stable statistic.

FIGURE 23 Lives saved build over time, mostly in low- and lower-middle-income countries

Net deaths averted under Coordinated resilience by period and income group, millions



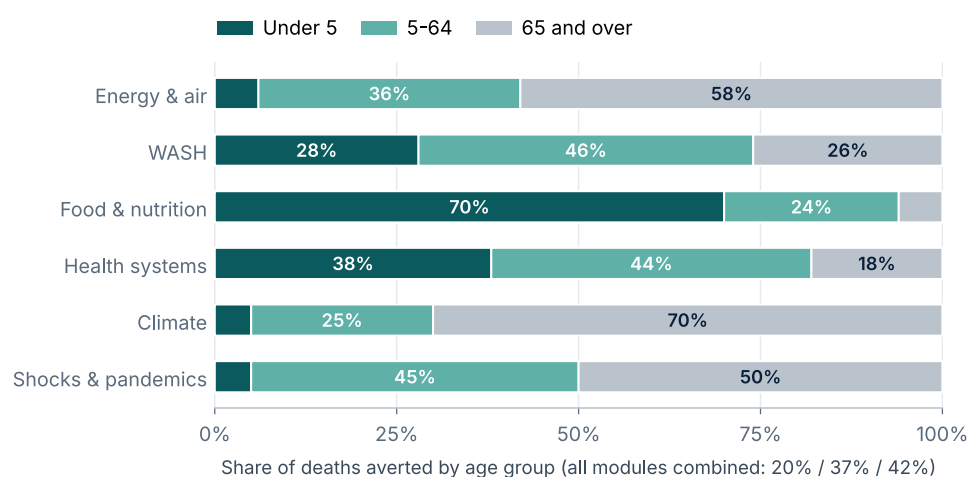
Source: H Heuristics HH-PRM v1.0. Income-group mapping held constant at 2025 classifications.

Generations

The timing of the benefit is a matter of justice as well as arithmetic. Only 54 million lives (15%) are saved before 2050; 153 million (42%) between 2050 and 2074; and 161 million (44%) from 2075 to 2100. Most of the people who benefit are therefore children alive today or people not yet born, while the costs are borne predominantly by adults now. This is a standard intergenerational structure, and it is the strongest argument for treating the programme as an investment rather than a transfer.

FIGURE 24 Children under five receive about 20% of lives saved; people over 65 about 42%

Age profile of deaths averted by pathway, share of pathway total



Source: H Heuristics HH-PRM v1.0; age shares are calibrations to published age profiles (Appendix A).

By age, 74 million of the lives saved (20%) are children under five, 138 million (37%) are aged 5 to 64 and 156 million (42%) are 65 or over. The first group gives most of the DALYs; the third reflects the ageing of populations later in the century.

CHAPTER 14

Cost, finance and value for money

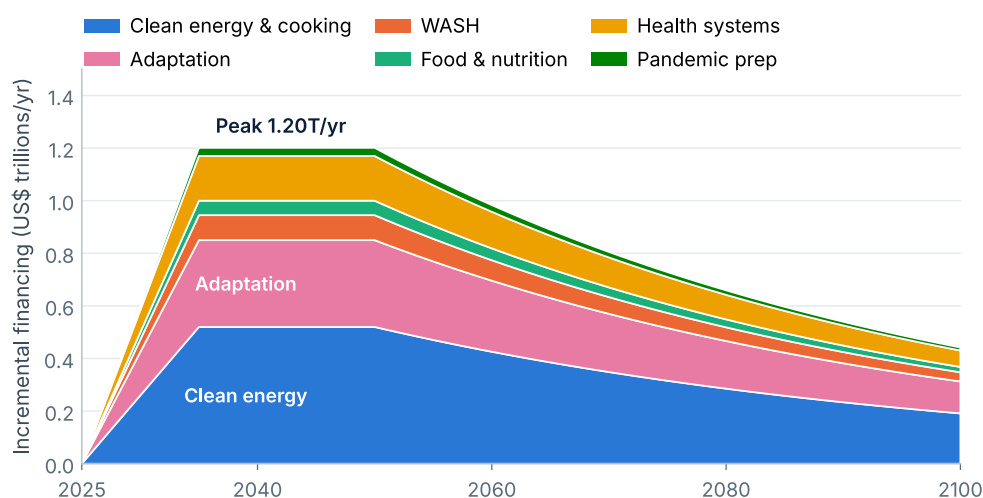
Coordinated resilience needs about \$1.2 trillion a year at its peak. Health benefits alone roughly repay it; climate, energy and growth benefits are on top.

The investment envelope

The model prices Coordinated resilience as **incremental financing above current trends**, in constant 2025 US dollars. Financing ramps up over ten years from 2026, holds until 2050, and then declines at 2% a year to a floor of 35% as backlogs are cleared and operations and maintenance dominate. The peak, 1,201 billion a year, is about 1% of global output at today's levels. Energy-transition spending is counted net of a 40% offset for lower fuel and operating costs (interval 20–60%).

FIGURE 25 Financing peaks near \$1.2 trillion a year, led by clean energy and adaptation

Incremental financing under Coordinated resilience, US\$ trillions a year, constant 2025 dollars, gross of energy savings



Source: H Heuristics HH-PRM v1.0.

TABLE 13 Financing components, peak annual need and present value

Component	Peak (US\$B/yr)	PV net (US\$T)	Anchor and evidence grade
Clean energy, grids and clean cooking	520	6.9	Calibrated to the investment-need trajectory for emerging and developing countries (ex-China) of about US\$2.4 trillion a year by 2030, net of current flows (IHLEG 2022); Judgement for the incremental share Judgement
Adaptation and resilience infrastructure	330	7.3	UNEP Adaptation Gap Report 2025: US\$310–365 billion a year by 2035 Anchored
Health systems and immunisation	170	3.7	H Heuristics benchmark against published universal-coverage costings Judgement
Water, sanitation and hygiene	95	2.1	H Heuristics benchmark against published universal-access costings Judgement
Food systems and nutrition	55	1.2	H Heuristics benchmark Judgement
Pandemic and outbreak preparedness	31	0.7	WHO/World Bank: about US\$31 billion a year; G20 panel: at least US\$34 billion Anchored
Total	1,201	21.8	

Present values at 3% real, 2025–2100, energy net of 40% operating-cost offset. Gross PV before the energy offset is US\$26.4 trillion.

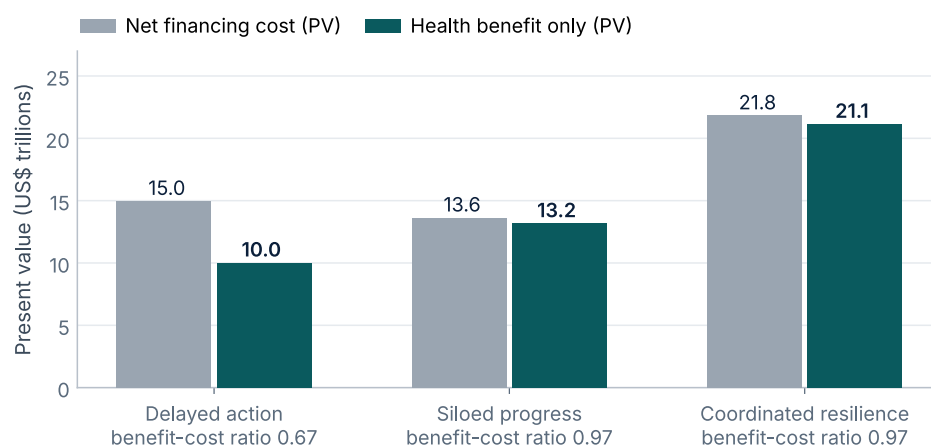
Set against today's resources the scale is sobering. Global official development assistance was US\$174.3 billion in 2025, and the full peak requirement is about seven times that.³ Domestic revenue, multilateral development banks, concessional and blended finance, and private capital must all carry part of the load. The independent expert group on climate finance suggested that about US\$1 trillion a year of external finance will be needed for emerging and developing countries by 2030.²²

Value for money

The model values health benefits only, at a deliberately low US\$5,000 per DALY held constant in real terms (interval US\$2,500 to 9,000), of the order of one year of average income per head in low- and middle-income countries. Present-value health benefits under Coordinated resilience are about \$21.1 trillion against net financing of \$21.8 trillion, a ratio of 0.97 (interval 0.55–1.54).

FIGURE 26 Health benefits alone roughly repay the programme; Delayed action does not

Present value of net financing and of health benefits, US\$ trillions, by scenario, 3% discount rate



Source: H Heuristics HH-PRM v1.0. Benefits exclude avoided climate damage, energy savings, productivity and growth.

Three conclusions follow. **Health alone breaks even** in the central case, so the case does not depend on non-health benefits, but nor is it an overwhelming health-only argument. **The benefit-cost ratio of Delayed action is only 0.67**, because costs rise and benefits arrive later and are discounted. And **Siloed progress is as efficient as Coordinated resilience per dollar (0.97)** but captures 135 million fewer lives; the extra spending between the two scenarios earns about the same return as the base programme. Non-health benefits make the case stronger: the Global Commission on Adaptation found returns of 2:1 to 10:1 for adaptation alone, and the Global Health 2035 commission found health benefits exceeding costs by 9 to 20 times when life-years are valued on a full-income basis.^{21,31}

TABLE 14 Cost per discounted DALY averted by pathway (health-only attribution)

Pathway	PV net cost (US\$T)	Discounted DALYs (B)	US\$ per DALY
Energy & air	4.1	1.16	3,544
WASH	2.1	0.45	4,639
Food & nutrition	1.2	0.76	1,597
Health systems	3.7	1.43	2,615
Climate	10.0	0.17	59,156
Shocks & pandemics	0.7	0.26	2,585

Energy-transition cost is split 60% to air quality and 40% to climate. Cost per DALY is only meaningful as a health programme metric for the health, water, nutrition and shock pathways; energy and adaptation investments are justified by far more than health.

Health, nutrition and shock pathways deliver healthy life-years at roughly US\$1,600 to US\$2,600 each in present value; water and sanitation at about US\$4,600, because most of its benefit is not health. Clean energy, at about US\$3,500 per DALY with no credit beyond the 40% offset, is below common thresholds of one to three times income per head. Climate, at about US\$59,000, cannot be justified by lives alone and is not meant to be: it protects assets, ecosystems and economies as well.

CHAPTER 15

Uncertainty, sensitivity and stress tests

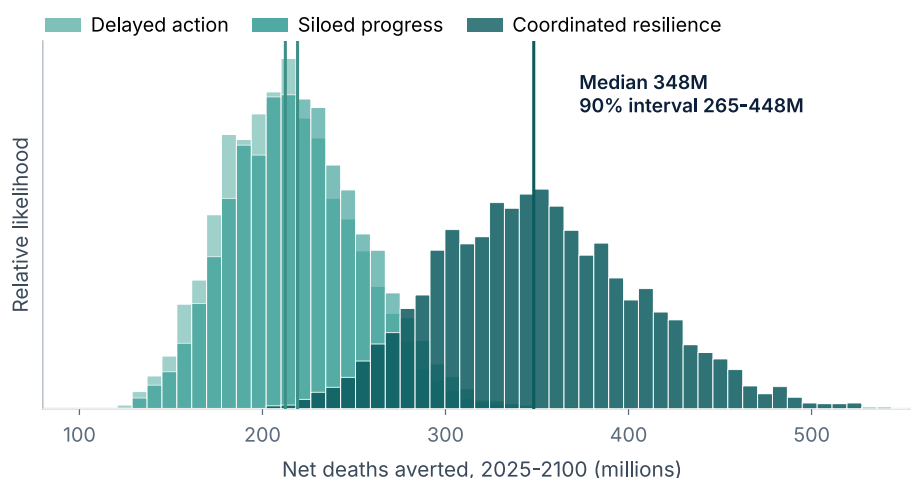
The estimate is wide but the answer is stable: even under adverse delivery, tens to hundreds of millions of lives remain at stake.

The distribution of outcomes

Across 5,000 joint Monte Carlo draws, net deaths averted by Coordinated resilience have a median of 348 million and a 90% interval of 265–448 million. The central case (368 million) sits slightly above the median because several uncertain parameters have skewed distributions. The distributions for Delayed action and Siloed progress overlap each other almost completely but barely overlap the distribution for Coordinated resilience: in the draws, Coordinated resilience beats both alternatives in 100% of cases.

FIGURE 27 Coordinated resilience outperforms the alternatives across the plausible range

Distribution of net deaths averted, 2025–2100, from 5,000 joint Monte Carlo draws; vertical lines mark medians



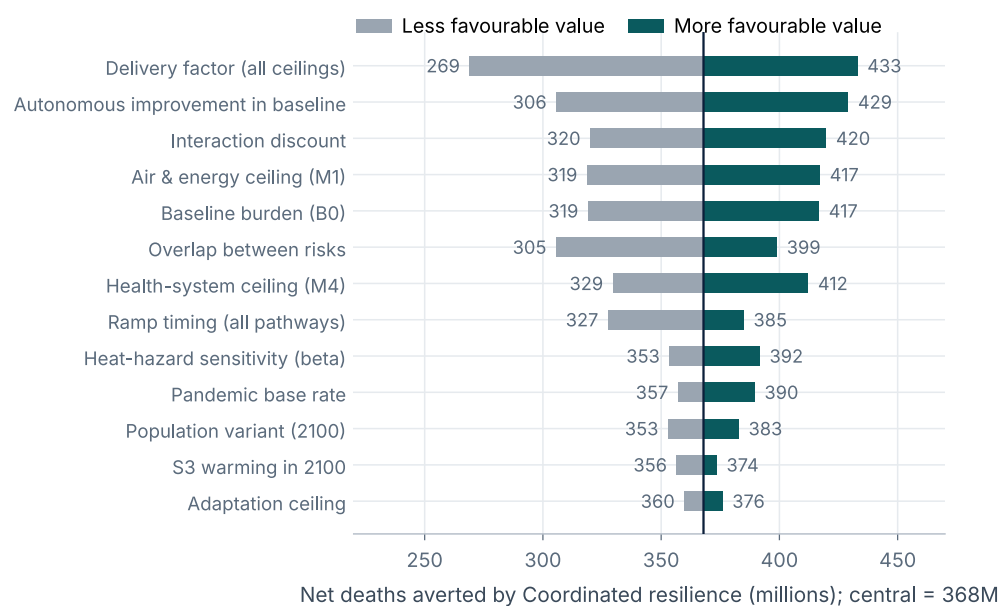
Source: H Heuristics HH-PRM v1.0.

What drives the answer

A one-at-a-time sensitivity analysis varies each assumption between a less and a more favourable value while holding others at central. The three most influential are **delivery factor (all ceilings)** (269 to 433 million), **autonomous improvement in baseline** (306 to 429 million) and **interaction discount** (320 to 420 million). Notably, the leading item is not a scientific parameter but the capacity to deliver; the baseline rate of autonomous progress is the second. Climate sensitivity, pandemic frequency and the 2100 temperature path move the result by well under 10% each.

FIGURE 28 Delivery capacity and the baseline rate of progress matter most

Net deaths averted by Coordinated resilience when each assumption is varied alone, millions; line marks the central case



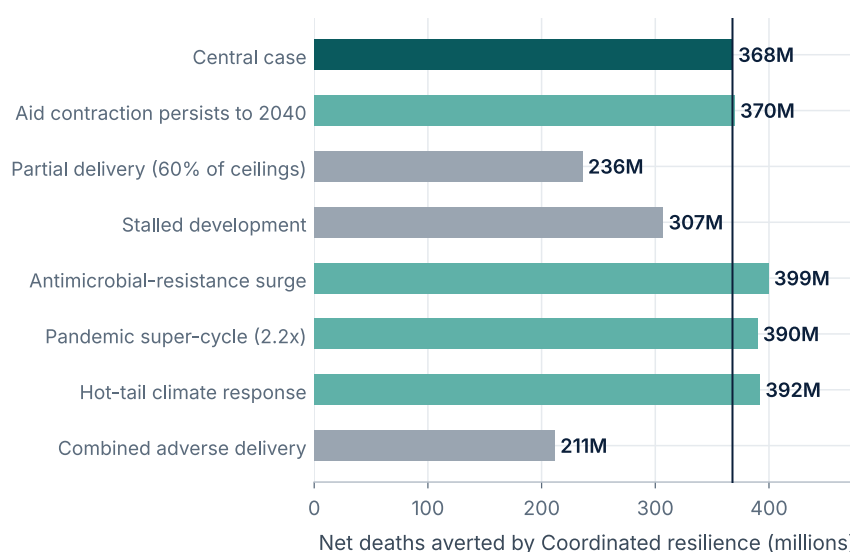
Source: H Heuristics HH-PRM v1.0.

Stress tests

Six plausible adverse conditions test whether the finding survives. Each is run as a full scenario, holding other parameters at central.

FIGURE 29 Even partial or delayed delivery averts more than 200 million lives

Net deaths averted by Coordinated resilience under stress conditions, millions; line marks the central case



Source: H Heuristics HH-PRM v1.0.

TABLE 15 Stress tests

Stress test	Net averted (M)	Reactive drift burden (M)	Interpretation
Central case	368	1,565	Reference
Aid contraction persists to 2040	370	1,595	Adds about 29 million deaths to the reactive baseline; little recovered because programmes rebuild slowly
Partial delivery (60% of ceilings)	236	1,565	Capacity shortfall everywhere at once cuts the benefit by about a third
Stalled development	307	1,785	Slower baseline progress raises the burden but lowers delivery capacity
Antimicrobial-resistance surge	399	1,724	A larger baseline burden raises the prize
Pandemic super-cycle (2.2×)	390	1,622	Preparedness is worth more in a riskier world
Hot-tail climate response	392	1,597	Higher heat sensitivity raises climate benefit
Combined adverse delivery	211	1,565	60% delivery and an eight-year slip: still a very large prize

What would change the conclusion

Three things would overturn it. If **baseline progress is far faster** than assumed, because for example technology cuts mortality faster than the model's per-person improvement rates, the margin for action shrinks. If **delivery capacity collapses** below roughly half of the model's ceilings, the programme still saves lives but the financing case weakens. And if **overlap between pathways is much larger** than assumed, a larger share of what looks like additional benefit is the same lives counted again; the model's overlap discount at twice its central value reduces the total to 305 million. None of the stress tests produces a result below 211 million lives, and every one is large relative to the programme's cost.

A STATEMENT OF CONFIDENCE

We are **highly confident** that coordinated, early action saves more lives than delayed or fragmented action; this holds in almost every Monte Carlo draw. We are **confident** that the benefit is of order hundreds of millions of lives, not tens of millions. We are **moderately confident** in the central estimate of 368 million, and in the ranking of pathways by contribution. We are **less confident** in the regional split, the nutrition baseline and the long-run climate contribution, which depend on working assumptions listed in the appendices.

CHAPTER 16

What efficient leadership looks like

Efficient leadership is less about vision than about sequencing, financing and accountability. The model points to seven principles and ten actions.

This report does not prescribe policy for any one country. But the pattern of results is consistent enough to say what a leadership agenda must contain to capture the gain from coordinated resilience rather than the lesser gain from delay or silos. It rests on seven principles.

- 1 Sequence for lives per dollar, and for what unlocks the rest.** Clean cooking, electricity for health facilities, safe water, primary care and immunisation, and nutrition have the shortest path from spending to survival, and every other pathway depends on them.
- 2 Finance where the lives are.** Two-thirds of the benefit accrues in low- and lower-middle-income countries, which face the highest cost of capital. Instruments that lower that cost (guarantees, concessional tranches, local-currency lending) are worth more than their face value.²²
- 3 Integrate delivery, not just ambition.** The gap between Siloed progress and Coordinated resilience is 135 million lives at similar cost per dollar. Shared targets, shared platforms (one community health worker, one distribution channel, one data system) and joint budgets across ministries are the mechanisms.
- 4 Build buffers before shocks.** Early warning, social protection and preparedness are cheap relative to the cascades they interrupt, and almost impossible to improvise.^{19,28,36}
- 5 Hold the baseline.** The 2025 contraction in aid is a direct attack on the Reactive drift path itself; programmes lost cannot be rebuilt at the same speed.^{3,4}
- 6 Measure outcomes, not outputs.** The scorecard below tracks deaths, deprivation and vulnerability rather than money spent, and publishes by region and income group.
- 7 Build institutions that outlast electoral cycles.** Most of the benefit arrives after 2050. Statutory targets, independent monitoring and multi-year financing compacts are how a 75-year payoff survives a four-year mandate.

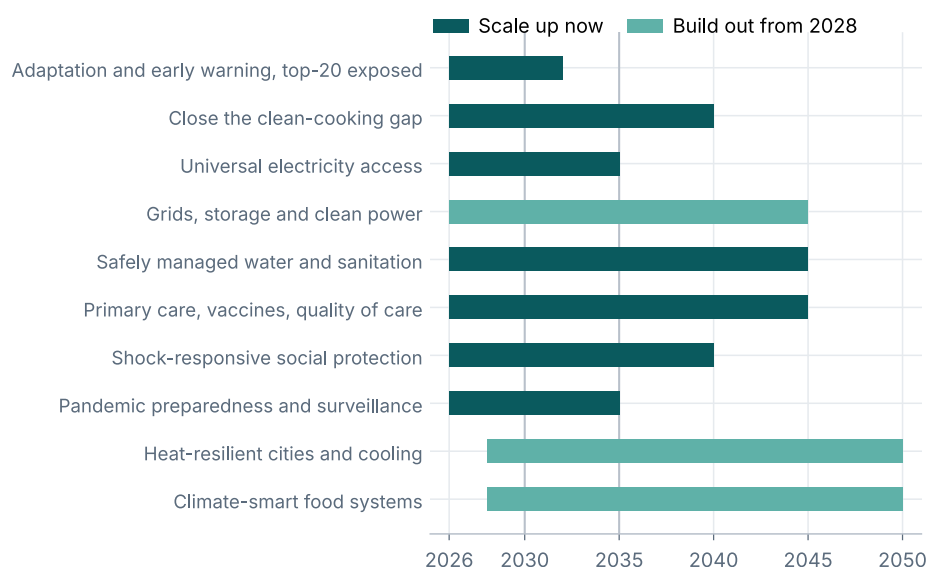
Ten priority actions

TABLE 16 Ten priority actions for the first decade

#	Action	Lead	Window	Outcome measure
1	Fund early warning and adaptation in the 20 most exposed countries	Climate funds, MDBs, national disaster agencies	2026–32	Disaster mortality; people covered by effective warning
2	Close the clean-cooking gap	Energy and health ministries, development banks	2026–40	Households using clean fuel; household-smoke deaths
3	Universal electricity access with priority to health facilities	Energy ministries, utilities, distributed-solar firms	2026–35	People and clinics with reliable power
4	Grids, storage and clean power in emerging economies; retire coal and diesel with just-transition support	Finance ministries, MDBs, private investors	2026–45	PM2.5 exposure; clean share of capacity
5	Safely managed water and sanitation at scale	Water utilities, local government	2026–45	People with safely managed services
6	Primary care, immunisation and quality of care	Health ministries, Gavi, Global Fund, WHO	2026–45	Amenable mortality; coverage index
7	Shock-responsive social protection	Social-protection ministries, ILO, World Bank	2026–40	Coverage in the most climate-vulnerable countries
8	Pandemic preparedness and surveillance system	WHO, regional bodies, G20	2026–35	Time to detect and contain; financing gap closed
9	Heat-resilient cities and cooling	City governments, building regulators	2028–50	Heat-related mortality; cooled shelter coverage
10	Climate-smart food systems and nutrition	Agriculture and nutrition ministries	2028–50	Hunger prevalence; child wasting and stunting

FIGURE 30 Ten actions, two horizons: scale up now, build out from 2028

Indicative delivery windows for the ten priority actions, 2026–2050



Source: H Heuristics. Windows are indicative and align with the ramp assumptions in HH-PRM v1.0.

An outcome scorecard

Because benefits arrive slowly, leaders need waypoints that show whether the trajectory is on track long before deaths averted become visible in statistics. **Table 17** gives the waypoints implied by Coordinated resilience for four outcomes, with the Reactive drift comparison for deprivation.

TABLE 17 Waypoints implied by Coordinated resilience

Year	Cumulative deaths averted (M)	People lacking ≥1 service, coordinated (B)	Same, reactive drift (B)	Air-pollution deaths (M/yr)	Amenable deaths (M/yr)	High-vulnerability people (B)
2030	1	3.54	3.78	7.8	8.4	3.37
2035	7	2.86	3.54	7.6	8.3	3.20
2040	19	2.12	3.31	7.2	8.1	2.94
2050	58	0.92	2.85	6.1	7.3	2.34

Source: HH-PRM v1.0, central case. A country or region falling materially behind these paths is, on the model's terms, still on the Reactive drift trajectory.

CHAPTER 17

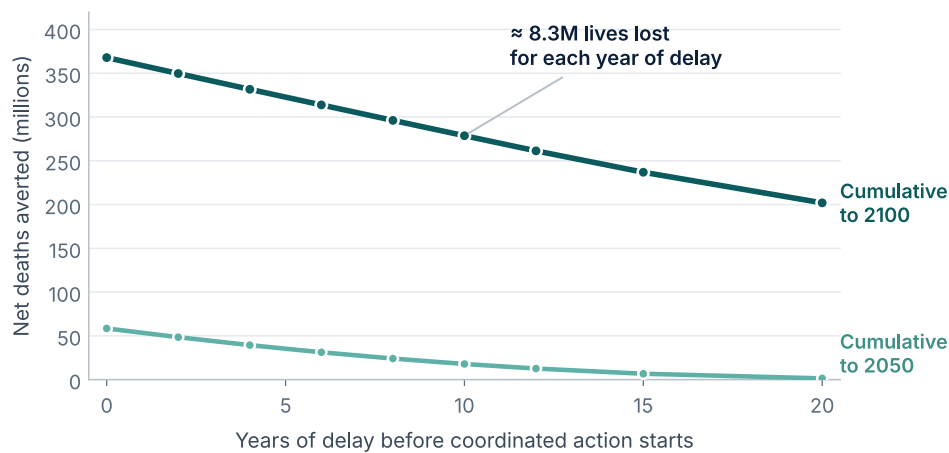
The cost of waiting

Each year of delay forfeits about 8.3 million lives. A decade of delay forfeits about 89 million.

Delay is the most common way in which policy fails: not through bad decisions but through deferred good ones. The model therefore asks a simple question: what if exactly the same Coordinated resilience programme started later? For each start delay it shifts every ramp by the same number of years, reduces ceilings for lock-in (0.6% per year of delay for energy and climate pathways, 0.3% for others), slows the temperature path toward the Delayed action pathway and raises costs.

FIGURE 31 Every year of delay costs about 8.3 million lives over the century

Net deaths averted by Coordinated resilience as a function of the delay before it starts, cumulative to 2050 and to 2100, millions



Source: H Heuristics HH-PRM v1.0.

TABLE 18 Lives forfeited by delay

Delay in start	Net deaths averted by 2100 (M)	Lives forfeited (M)	Averted by 2050 (M)	Healthy life-years (B DALYs)
0 years	368	0	58	13.6
2 years	350	18	49	12.9
4 years	332	36	39	12.2
6 years	314	54	31	11.6
8 years	296	72	24	10.9
10 years	279	89	18	10.3
12 years	261	107	13	9.6
15 years	237	131	7	8.7
20 years	202	166	1	7.4

Lock-in assumptions are H Heuristics judgements; if lock-in were zero the loss would still be roughly 6 million lives per year of delay, because the ramps simply start later.

The average of 8.3 million lives a year equals about 16 lives every minute of delay. Three features of the curve matter. It is **nearly linear**: there is no point at which it is too late, and no point at which it is safe to wait. It is **steepest for the 2050 horizon**: a 10-year delay cuts the lives saved by 2050 from 58 to 18 million, and a 20-year delay all but erases them. And it is **largest for the climate-sensitive pathways** where lock-in is strongest: infrastructure built for a hotter, more polluted world is expensive to retrofit.

THE ARITHMETIC OF URGENCY

Delay a decade and the world forfeits about 89 million lives, roughly equivalent to the 91 million deaths estimated to have been averted by one large donor's programmes over twenty years.⁴ It does so by choice, not by constraint, because the programme's cost is about 1% of world output. A leader who delays ten years is making a decision whose human cost is comparable to the major catastrophes of the last century.

CHAPTER 18

Limitations and research agenda

This is a first scenario model. Its omissions mostly understate the benefit, but its parametric structure and judgement-based ceilings are real limits.

What the model omits

- **Causes of death outside the six pathways.** Tobacco, hypertension, obesity and other non-communicable risks (high blood pressure alone accounts for 8.4% of global DALYs²⁶); injuries; conflict; lead and chemical pollution; biodiversity loss and mental health. Including them would raise the total.
- **Climate impacts beyond heat and extremes.** Sea-level rise, ecosystems, crop yields at the regional scale, displacement and conflict, and all impacts after 2100.
- **Feedback from health to growth.** A healthier population earns, learns and saves more; the model does not feed this back into development. The omission is conservative.
- **Non-health benefits.** Energy savings beyond a fixed offset, avoided climate damages, productivity, time savings and dignity.

Structural limits

- **Parametric, not mechanistic.** Pathways are expressed as attributable baselines multiplied by ceilings and ramps. They do not simulate exposure, disease dynamics or economies at the country level.
- **Ceilings and timing are judgements.** They are bracketed by wide ranges and reported separately in the sensitivity analysis, but they are not estimated statistically.
- **Regional resolution.** Six regions with allocation weights; income-group mapping is static.
- **Data vintage.** Baselines refer to 2019 to 2024, and some anchors (for example the amenable-mortality estimate for 2016) are older than we would like.
- **Overlap is imperfectly known.** The overlap and interaction discounts are central to avoiding double counting, but they are calibrated by judgement rather than by joint estimation.

Ethical choices embedded

Deaths are counted undiscounted and equally regardless of age; DALYs value young lives more; costs are discounted at 3% while health benefits are reported both ways; and the valuation of US\$5,000 per DALY is the same for everyone, which understates the value of avoided suffering in richer countries and overstates it in the poorest. These are defensible conventions, but they are choices.

Research agenda for version 2

TABLE 19 Planned improvements

Improvement	Why it matters
Country-level module for 40 priority countries	Replaces regional allocation weights with national burdens and delivery capacity; allows policy-relevant country results
Joint overlap estimation from comparative risk assessment data	Replaces judgement-based discounts with empirical interaction estimates
Endogenous growth and fiscal-space link	Lets development gains feed back into delivery capacity and finance
Expanded causes: non-communicable risks, injuries, conflict, chemical pollution	Closes the largest known omission
Structured expert elicitation of ceilings and timing	Turns judgement into documented, challengeable distributions
External peer review and open model release	Independent audit of the structure and parameters

APPENDICES

Appendix A · Parameter register

Every parameter of HH-PRM v1.0, so that readers can challenge, reproduce or replace any assumption.

A.1 Pathway parameters

TABLE 20 Mortality pathway parameters (central values)

Pathway	2025 base (M/yr)	Pop exp. a	Age exp. b	Autonomous improv. d	S3 ceiling (range)	Ramp mid / width	Overlap ω	YLL / non- fatal
Energy & air	7.9	1.0	0.6	1.5%	40% (25–55%)	2042 / 9	8%	24 / +20%
WASH	1.3	1.0	0.0	2.5%	85% (70–95%)	2037 / 6	18%	48 / +10%
Food & nutrition	2.0	0.8	0.0	1.8%	60% (40–75%)	2040 / 8	22%	58 / +45%
Health systems	8.4	1.0	0.5	1.2%	33% (20–48%)	2043 / 10	25%	38 / +30%
Climate	0.6	1.0	0.65 share	0.6%	45% (30–60%)	2040 / 8	5%	12 / +15%
Shocks & pandemics	0.95	1.0 / 0.7	0	n/a	freq –25%, severity –40%, humanitarian –35%	2038 / 7	8%	17 / +35%

Climate: base = heat plus extreme-event deaths; hazard exponent 0.6 per °C (0.35–0.90); age sensitivity share 0.65; vulnerability decays at the autonomous rate shown. Shocks: base = expected pandemic (0.45) plus humanitarian (0.50) deaths; pandemic frequency 4.5% a year, median severity 3.5 million, log-sd 1.6, cap 80 million.

TABLE 21 Scenario scaling of the Coordinated ceilings

Pathway	S2 Siloed (share of S3 ceiling)	S1 Delayed (share of S3 ceiling)
Energy & air	70%	85%
WASH	75%	90%
Food & nutrition	55%	90%
Health systems	75%	90%
Climate	55%	80%
Shocks & pandemics	45%	85%

S2 ramps are 3 years slower than S3; S1 starts in 2040 with ramps 14 years later. Costs: S2 at 40–80% of S3 by component; S1 at 1.25× S3 shifted 14 years.

A.2 Lives-improved parameters

TABLE 22 Deprivation services

Service gap	2025 stock (B)	Autonomous decline κ	S3 ceiling	Ramp mid / width	Warming penalty
No electricity access	0.64	2.0%	97%	2034 / 4	no
No clean cooking	2.05	1.7%	92%	2042 / 6	no
No safely managed water	2.08	2.5%	93%	2040 / 6	no
No safely managed sanitation	3.40	2.0%	90%	2045 / 7	no
Chronic hunger	0.67	3.5%	85%	2036 / 5	yes
Extreme poverty (\$3/day)	0.81	2.5%	70%	2045 / 8	yes
Lacking essential health coverage	4.60	1.5%	75%	2042 / 8	no
No social protection	3.80	2.2%	80%	2042 / 8	no

Stocks: electricity 0.64 (666 million in 2023, trended), clean cooking 2.05, water 2.08, sanitation 3.40, hunger 0.67, poverty 0.81 (2025 projection), UHC 4.6, social protection 3.8. Unique persons lacking ≥ 1 of the first six = $0.42 \times \text{sum}$. Warming penalty $\exp(0.30 \times \Delta T)$. High-vulnerability baseline 3.45 billion; hazard $\exp(0.35 \times \Delta T)$; S3 reduction ceiling 55%.

A.3 Uncertainty distributions

Monte Carlo draws use triangular distributions (low, mode, high): delivery factor (0.70, 1.00, 1.20); ceilings as in A.1; autonomous improvement $\times(0.7, 1.0, 1.3)$; baseline burdens $\times(0.85, 1.0, 1.15)$; hazard exponent (0.35, 0.60, 0.90); adaptation ceiling (0.30, 0.45, 0.60); climate base $\times(0.85, 1.0, 1.30)$; autonomous vulnerability decline (0.3%, 0.6%, 1.0%); pandemic base $\times(0.4, 1.0, 2.2)$; humanitarian base $\times(0.6, 1.0, 1.6)$; pandemic severity cut (15%, 40%, 60%); frequency cut (5%, 25%, 40%); overlap scale (0.5, 1.0, 2.0); interaction discount (0.80, 0.92, 1.05); ramp timing shift (-4, 0, +8 years); 2100 population $\times(0.93, 1.0, 1.07)$; 2100 warming under S3 (1.65, 1.85, 2.20 °C); value per DALY (US\$2,500, 5,000, 9,000); energy offset (20%, 40%, 60%).

A.4 Evidence grading

Anchored parameters: 2025 baselines for air pollution, health-system amenable deaths, WASH deaths, heat deaths; service stocks; population totals; 2100 warming under Reactive drift; adaptation and pandemic financing needs. **Calibrated** : autonomous improvement rates; climate hazard form; DALY conversion factors; deprivation decline rates (checked against published trajectories, for example 512 million hungry in 2030). **Judgement** : ceilings and ramp timing for every pathway; overlap discounts; nutrition and expected-shock baselines; regional allocation weights; lock-in rates.

Appendix B · Allocation weights and demography

Regional population, allocation weights and delivery weights used in Chapter 13.

TABLE 23 Regional population and allocation weights

Region	Pop. 2025 (B)	2050	2100	Air	WASH	Food	Health	Climate	Shocks	Delivery weight
Sub-Saharan Africa	1.30	2.15	3.50	9%	46%	55%	30%	15%	25%	0.90
South Asia	2.05	2.45	2.40	37%	35%	30%	30%	28%	22%	1.00
East Asia & Pacific	2.40	2.30	1.55	34%	8%	5%	22%	22%	15%	1.05
MENA & Central Asia	0.67	0.90	0.90	7%	8%	7%	9%	8%	12%	1.00
Latin America & Caribbean	0.67	0.73	0.60	3%	2%	2%	7%	5%	8%	1.05
High-income West & other	1.12	1.17	1.23	10%	1%	1%	2%	22%	18%	1.05

Allocation weights are each region's share of the pathway's baseline attributable deaths in 2025 (H Heuristics working assumptions informed by the distributions cited in Chapters 4–8); weights evolve with each region's population and are normalised each year. Population approximates UN WPP 2024 medium variant aggregates.

Appendix C · Results by decade

TABLE 24 Net deaths averted by decade, millions

Period	Air	WASH	Food	Health	Climate	Shocks	S3 total	S2 total	S1 total
2025–2034	2	1	1	1	0	0	6	3	0
2035–2044	10	3	3	6	2	2	26	14	1
2045–2054	18	5	5	12	4	4	48	29	14
2055–2064	23	4	5	17	6	6	61	39	33
2065–2074	24	3	4	18	8	7	66	43	46
2075–2084	23	3	4	18	10	8	65	42	51
2085–2100	32	3	5	25	18	14	97	63	79
Total	132	22	26	98	49	42	368	232	225

Pathway columns are Coordinated resilience (S3).

Appendix D · Source register

Sources cited in the report, with verification grade.

Grades: **V** headline figure confirmed against the publisher's page or summary during the October 2026 desk check; **S** confirmed through secondary coverage only; **K** cited from the authors' prior knowledge and not re-verified in this edition. Check primary texts before external citation.

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Appendix E · Glossary

DALY

Disability-adjusted life-year: one lost year of healthy life, combining years of life lost to premature death and years lived with disability.

Polycrisis

A situation in which crises in several global systems become causally entangled in ways that significantly degrade humanity's prospects, producing harms greater than the sum of those the crises would cause alone.

Attributable deaths

Deaths that would not have occurred had a risk factor been at a reference level. Attributable deaths from different risks overlap and are not additive.

Amenable mortality

Deaths from conditions that timely, good-quality health care could prevent.

Net deaths averted

Deaths averted relative to Reactive drift after removing overlap between pathways and applying the interaction discount.

Delivery factor

A parameter shared across all pathways that scales every ceiling, representing the capacity of governments and institutions to implement.

Ceiling

The maximum share of a pathway's Reactive drift deaths that a scenario can remove.

Mitigation / adaptation

Reducing greenhouse-gas emissions to limit warming / reducing the vulnerability of people and systems to the warming that occurs.

Global South

In this report, low-, lower-middle- and upper-middle-income countries.



H Heuristics

Transparent, decision-oriented research on complex systems. This report is the first in the Polycrisis Resilience series.

Scenario estimates, not forecasts. HH-PRM v1.0 has not been peer reviewed. Figures are rounded; sources are graded in Appendix D. © 2026 H Heuristics. All rights reserved.