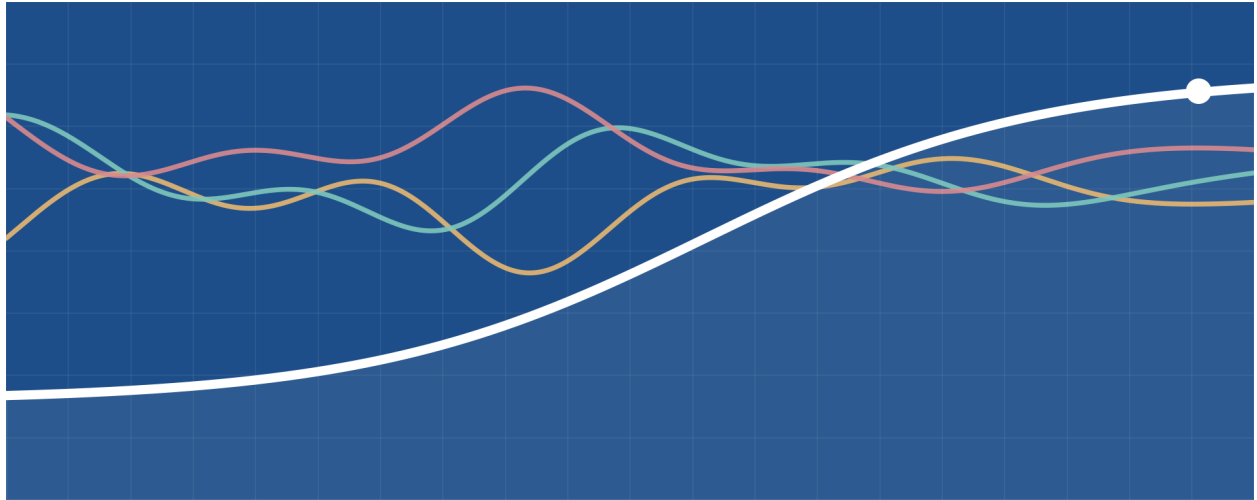




H HEURISTICS

Navigating a Changing World

Building Adaptive Capacity for the Twenty-First Century

Strategies for Thriving Amid Climate, Pollution, and Instability

Hunter Hughes

H Heuristics · Research Report · October 2026

About This Report

Title: Building Adaptive Capacity for the Twenty-First Century: Strategies for Thriving Amid Climate, Pollution, and Instability

Author: Hunter Hughes, H Heuristics

Publication: H Heuristics Research Report, October 2026

Suggested citation: Hughes, H. (2026). Building Adaptive Capacity for the Twenty-First Century: Strategies for Thriving Amid Climate, Pollution, and Instability. H Heuristics Research Report.

About H Heuristics. H Heuristics publishes independent research on how societies can navigate the interacting pressures of climate change, pollution, technological change and geopolitical instability. Its reports synthesise public evidence, state their assumptions, and link every quantitative claim to a primary or authoritative source.

How to read the sources. Blue underlined text throughout the report is a hyperlink to the cited source. A consolidated reference list appears at the end. Figures and tables are numbered in order of appearance and are listed after the table of contents.

Disclaimer. This report is provided for information and discussion. It is analytical rather than predictive and does not constitute investment, legal, medical or policy advice. Statistics are reproduced from the cited sources, which may revise them; figures that H Heuristics derived or illustrated are labelled as such. Current-events material reflects information available in early October 2026.

© 2026 H Heuristics. All rights reserved.

Abstract

The twenty-first century is being shaped by three pressures acting on the same people at the same time: a warming climate, a polluted environment, and a more unstable political and economic order. Each is large on its own — 2025 was the second or third warmest year on record, air pollution contributed to 7.9 million deaths in 2023, and 2025 saw 65 conflicts involving states, the most since records began — but what distinguishes the present is their interaction. A heatwave becomes a harvest failure, a price spike, a fiscal squeeze and a displacement crisis; an energy-supply shock becomes a pollution crisis as households return to dirtier fuels. Repeated shocks can ratchet systems downward, because each one erodes the buffers needed to absorb the next.

This report argues that the variable that most reliably separates societies damaged by compound stress from those that come through it intact is adaptive capacity: the standing ability to anticipate, absorb, adapt to and, where necessary, transform in the face of shocks. It organises capacity into a five-layer Capacity Stack — sense and anticipate; buffer; distribute and diversify; protect people; and govern, finance and learn — and shows how each layer pays off against all three stressors. The report quantifies the gaps: international public adaptation finance of about US\$26 billion in 2023 against estimated needs of US\$310–365 billion a year by 2035; US\$921 billion of net interest paid by developing countries in 2024; and a pollution burden that exceeds the measured toll of heat, disasters and conflict.

Two arguments distinguish the analysis. First, pollution control and clean energy are treated as adaptation investments, not only as mitigation: Beijing's two-thirds cut in particulate pollution, the global phase-out of leaded petrol and the Montreal Protocol show that exposure can be cut fast, and the same measures strengthen health, productivity, fiscal buffers and energy security. Second, capacity must be designed for instability as well as weather, which favours reduced dependence, modularity, flexible finance and local control over attempts to forecast political shocks. Seven case studies — Bangladesh, Ahmedabad, Beijing, the Netherlands, Singapore, Ethiopia and Barbados — show that capacity is buildable at many income levels where institutions, budgets and feedback loops are sustained.

The report concludes with actor-specific strategies, a three-phase roadmap to 2050, a capacity scorecard, an analysis of the ways adaptation can fail, and ten commitments. Its central finding is that thriving under compound stress is a matter of design and timing: capacity built early, for more than one stress at a time, is cheaper, more effective and more equitable than capacity improvised after the damage is done.

Keywords: adaptive capacity; resilience; compound risk; polycrisis; climate adaptation; air pollution; clean energy; early warning; adaptive social protection; adaptation finance; fiscal space; fragility and conflict; decision-making under deep uncertainty; maladaptation

Data and method: Synthesis of institutional and peer-reviewed research, official statistics and country case material, including the WMO *State of the Global Climate 2025*, UNEP *Adaptation Gap Report 2025* and *Emissions Gap Report 2025*, *State of Global Air 2025*, the 2025 *Lancet Countdown*, UCDP, IDMC, FAO *SOFI 2026*, UNCTAD *A World of Debt*, IEA *World Energy Investment 2026* and Munich Re loss data. Conceptual figures are labelled as such. The analysis is a framework and synthesis, not a forecast.

Key Findings at a Glance

7.9 million deaths attributed to air pollution in 2023 (State of Global Air 2025)	546,000 heat-related deaths a year, 2012–2021 average (Lancet Countdown 2025)	65 conflicts involving states in 2025, the most since 1946 (UCDP)	7 of 9 planetary boundaries now transgressed (Planetary Health Check 2025)
US\$224bn natural-disaster losses in 2025, about half uninsured (Munich Re)	12–14× gap between adaptation finance needs and current international public flows (UNEP 2025)	US\$921bn net interest paid by developing countries in 2024 (UNCTAD)	645 million people facing hunger in 2025, down but fragile (FAO SOFI 2026)

- **Stresses compound, and repeated shocks ratchet systems down.** Climate, pollution and instability transmit through food, health, energy, finance, displacement and institutions. Capacity must be designed for the combination.
- **Adaptive capacity is the right target.** It can be organised as a five-layer Capacity Stack — sense, buffer, distribute, protect, govern — each layer paying off against all three stressors.
- **Pollution control is adaptation.** Cleaner air, water and energy raise health, productivity and fiscal and energy security. Beijing cut PM2.5 by about two-thirds in a decade.
- **Early warning and basic protection are the best buys.** Bangladesh cut cyclone deaths from about 300,000 (1970) to about a dozen (2020); Ahmedabad's heat plan is estimated to avoid about 1,190 deaths a year.
- **Money is the binding constraint.** Adaptation finance is 12–14 times below need, and the fiscal buffers of the most exposed countries are the thinnest.
- **Design for instability by reducing dependence.** Distributed energy, diversified supply, flexible finance and local institutions work under political shocks as well as weather.
- **Move early and keep learning.** Capacity built before the shock is cheaper than capacity improvised after it, and standards set in the next fifteen years lock in exposure or resilience through 2050.

Contents

1. Introduction: Thriving Under Compound Stress	6
2. The Triple Stress: Where the Evidence Stands	8
3. How Stresses Compound: From Polycrisis to Policy	12
4. Adaptive Capacity: A Working Framework	15
5. Layer 1 — Sense and Anticipate	18
6. Layer 2 — Buffer: Fiscal Space, Insurance and Natural Capital	20
7. Layer 3 — Distribute and Diversify: Energy, Water and Food Systems	22
8. Layer 4 — Protect People: Health, Social Protection and Skills	25
9. Layer 5 — Govern, Finance and Learn	27
10. Pollution Control as Adaptation Strategy	29
11. Building Capacity Under Instability	33
12. Seven Case Studies in Capacity	35
13. Strategies for Each Actor and a Phased Roadmap	37
14. Risks, Limits and the Ways Adaptation Fails	40
15. Conclusion: An Agenda for Thriving	42
References and Further Reading	44

List of Figures

Figure 1. Disaster losses remain high and largely uninsured	8
Figure 2. Pollution is the largest of the measured mortality burdens	9
Figure 3. Hunger is edging down but remains high	10
Figure 4. Seven of nine planetary boundaries are transgressed	11
Figure 5. How the three stressors compound	13
Figure 6. Capacity determines whether compound shocks ratchet a system down or build it up	14
Figure 7. The Capacity Stack	16
Figure 8. Cyclone deaths in Bangladesh fell by orders of magnitude	18
Figure 9. The adaptation finance gap	21
Figure 10. Clean energy now attracts almost twice the investment of fossil fuels	23
Figure 11. Some strategies perform well in every scenario	27
Figure 12. Beijing cut PM2.5 by roughly two-thirds in a decade	30
Figure 13. A three-phase roadmap for building adaptive capacity to 2050	38

List of Tables

Table 1. Six channels through which climate, pollution and instability compound	12
Table 2. The Capacity Stack: purpose, instruments and indicators	16
Table 3. Pollution-control measures and their adaptation co-benefits	31
Table 4. Seven cases mapped to the Capacity Stack	35
Table 5. Priority strategies by actor	37
Table 6. A proposed adaptive-capacity scorecard	39

1. Introduction: Thriving Under Compound Stress

The twenty-first century will not be defined by any single crisis. It will be defined by three slow-moving pressures — a warming climate, a polluted environment, and a more unstable political and economic order — acting on the same people, in the same places, at the same time. The question this report asks is not how societies can survive each pressure in isolation, but how they can build the standing capacity to keep thriving while all three press at once.

Public policy has traditionally treated these pressures as separate files. Climate adaptation sits in one ministry, air and water quality in another, and security, trade and fiscal stability in a third. Each has its own data, budgets, experts and international negotiating track. Yet the people on the receiving end do not experience them separately. A farmer in the Indo-Gangetic Plain faces a hotter growing season, ozone damage to her crops, and a fertiliser price set by events in the Gulf. A child in Lagos breathes air thick with particulates from generators that run because the grid failed, in a country whose debt service is crowding out the health budget. The cascade between these pressures is the real object of concern.

The evidence that the pressures are intensifying is substantial. The World Meteorological Organization reports that [2015 to 2025 were the eleven warmest years on record](#), with 2024 the first calendar year to exceed 1.5°C above the pre-industrial average. The UN Environment Programme's [Emissions Gap Report 2025](#) projects 2.3–2.5°C of warming this century if national pledges are fully implemented and about 2.8°C on current policies. Air pollution contributed to [7.9 million deaths in 2023](#). The Uppsala Conflict Data Program recorded [65 conflicts involving states in 2025](#), the most since records began in 1946. And the World Economic Forum's [Global Risks Report 2026](#) found that half of the leaders and experts it surveyed expect a turbulent or stormy world over the next two years.

This report takes those facts as its starting point and turns to what can be done. Its central argument is that **adaptive capacity** — the standing ability of a society to anticipate, absorb, adapt to and, where necessary, transform in the face of shocks — is the variable that most reliably separates communities that are damaged by compound stress from those that come through it intact or even stronger. Capacity is not a forecast of any particular hazard. It is a general-purpose asset, and like any asset it can be built, financed, maintained and, if neglected, run down.

The report makes five claims. First, that climate, pollution and instability are best understood as a single interacting system of stress rather than three parallel problems (Sections 2 and 3). Second, that adaptive capacity can be organised into a five-layer **Capacity Stack** — sensing, buffering, distributing, protecting people, and governing and learning — each layer of which pays off against all three stressors (Sections 4 to 9). Third, that pollution control and clean energy are not only mitigation measures but among the most powerful adaptation investments available, because they raise health, productivity and fiscal resilience simultaneously (Section 10). Fourth, that capacity must be designed to hold under conflict and geoeconomic shock as well as under weather (Section 11). Fifth, that the evidence from places that have built capacity — Bangladesh, Ahmedabad, Beijing, the Netherlands, Singapore, Ethiopia, Barbados — shows it is achievable, affordable and fast enough to matter (Section 12).

1.1 What “thriving” means

Resilience discussions often settle for survival: the system returns to where it was. That is too modest a goal. A society that merely bounces back to a pre-shock state remains exposed to the next one, and many pre-shock states were themselves unsafe — consider a city restored to the polluted, flood-prone and unequal condition it occupied before the storm. This report uses *thriving* to mean three things at once: people are protected from the

worst outcomes (survival); the economy and public finances keep functioning through the shock (continuity); and the system emerges better able to handle the next shock than the last (improvement). The third element is what the resilience literature calls *bouncing forward*, and it is what turns adaptation spending from a cost into an investment.

1.2 Scope, method and reading guide

The report synthesises institutional and peer-reviewed research, official statistics, and country case material. Every quantitative claim is attributed inline, with a hyperlink to the primary or authoritative secondary source, and the reference list at the end groups sources by theme. Where figures are conceptual or illustrative rather than empirical, the figure caption says so. Estimates from different institutions use different methods and are not always strictly comparable — for example, modelled estimates of deaths attributable to pollution and recorded counts of deaths from disasters measure different things — and the text flags these limits where they matter. The analysis is a synthesis and a framework, not a forecast.

Section 2 sets out the state of the three stressors. Section 3 explains why they compound. Section 4 defines adaptive capacity and introduces the Capacity Stack. Sections 5 to 9 take the five layers in turn. Section 10 treats pollution control as adaptation, and Section 11 treats instability. Section 12 presents seven case studies. Section 13 sets out strategies for each major actor and a phased roadmap. Section 14 examines risks, limits and the ways in which adaptation can fail, and Section 15 concludes with an agenda.

2. The Triple Stress: Where the Evidence Stands

Climate change, pollution and instability are each, taken alone, among the largest threats to human welfare. Taken together they form a system of stress that is wearing down the buffers on which societies depend. This section summarises the state of each stressor and the planetary context in which they operate.

2.1 Climate: a hotter baseline and costlier extremes

The physical signal is unambiguous. The WMO's [State of the Global Climate 2025](#) reports that 2025 was the second or third warmest year on record, at about 1.43°C above the 1850–1900 average, and that the eleven years from 2015 to 2025 are the eleven warmest observed. The report also highlights Earth's energy imbalance, which reached a new high in 2025. Current policies are not on track to reverse the trend: UNEP's [Emissions Gap Report 2025](#) finds that warming of 1.5°C by 2100 remains possible only with much deeper cuts, and expects the multi-decadal average to exceed 1.5°C at least temporarily.

The human exposure is large. The IPCC's [Sixth Assessment Report, Working Group II](#) estimates that between 3.3 and 3.6 billion people live in contexts that are highly vulnerable to climate change. Heat is already a leading channel. The [2025 Lancet Countdown](#) estimates that heat-related deaths averaged about 546,000 a year in 2012–2021, a 63 per cent rise in the total since the 1990s (23 per cent when expressed as a rate per 100,000 people, which strips out population growth and ageing). Heat is also a labour-market shock: the International Labour Organization estimates that [2.41 billion workers — about 71 per cent of the global workforce — were exposed to excessive heat](#) in 2020, and that exposure is highest in Africa, where it reaches 92.9 per cent.

The economic record shows the same pattern. Munich Re estimates that [natural disasters caused about US\\$224 billion of losses in 2025, of which about US\\$108 billion was insured](#); the previous year's inflation-adjusted figures were US\$368 billion and US\$147 billion. Insured losses topped US\$100 billion in both 2024 and 2025, and the Los Angeles wildfires alone cost an estimated US\$53 billion. Weather-related events accounted for 92 per cent of all 2025 losses. The WMO's longer record, its [Atlas of Mortality and Economic Losses](#), counts nearly 12,000 weather, climate and water-related disasters between 1970 and 2021, with about 2 million deaths and US\$4.3 trillion in reported losses; 90 per cent of the deaths occurred in developing countries, even as better early warning has driven mortality down.

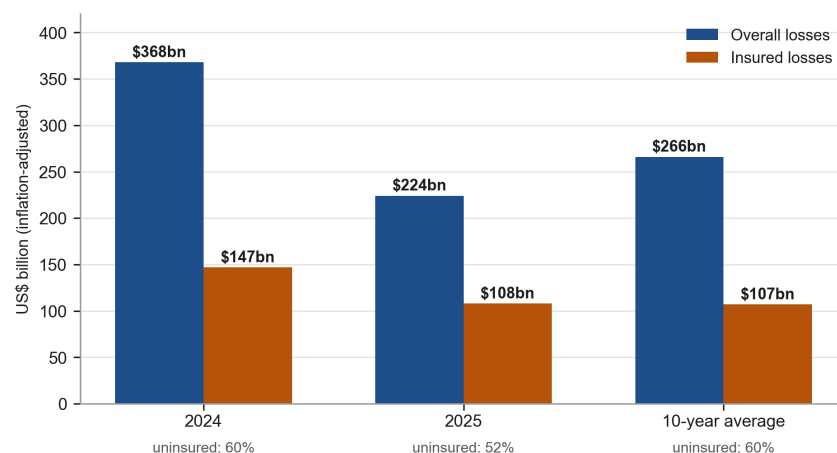


Figure 1. Disaster losses remain high and largely uninsured. Overall and insured natural-disaster losses, 2024, 2025 and the ten-year average (US\$ billion, inflation-adjusted).

Source: Munich Re annual natural catastrophe analysis, as reported by Clean Energy Wire (2026). Uninsured share calculated by H Heuristics.

2.2 Pollution: the largest environmental killer

Pollution receives less attention than climate but causes more recorded harm. The [State of Global Air 2025](#) report, produced by the Health Effects Institute and the Institute for Health Metrics and Evaluation, attributes 7.9 million deaths in 2023 to air pollution, of which 6.8 million (86 per cent) were from non-communicable diseases such as heart disease, stroke, lung disease and diabetes, and links air pollution to more than 625,000 dementia deaths. India and China each recorded more than 2 million attributable deaths. Earlier work by the [Lancet Commission on Pollution and Health](#) put the toll from all forms of pollution at 9 million deaths in 2019, one in six deaths worldwide, with air pollution accounting for roughly three-quarters of them and low- and middle-income countries bearing the overwhelming majority.

The economic cost is also very large. The World Bank estimates that the [health damage from fine-particle air pollution cost about US\\$8.1 trillion in 2019, or 6.1 per cent of global GDP](#). Children bear a distinctive burden through lead: a [UNICEF and Pure Earth analysis](#) found that up to 800 million children — roughly one in three — have blood lead levels at or above the 5 micrograms per decilitre threshold for action, with informal recycling of lead-acid batteries a leading source, at an estimated cost of nearly US\$1 trillion in lost lifetime economic potential in low- and middle-income countries. Nearly everyone is exposed to unsafe air: the WHO's [air-quality database update](#) found that around 99 per cent of the world's population breathes air that exceeds guideline limits.

Water, sanitation and cooking complete the picture. The WHO/UNICEF [2025 update](#) estimates that about 2.1 billion people lacked safely managed drinking water in 2024 and 3.4 billion lacked safely managed sanitation, and roughly 2.1 billion still lack clean cooking, according to [Tracking SDG7](#) — a deficit that is simultaneously a household air-pollution crisis, a deforestation driver and a gender-equity problem.

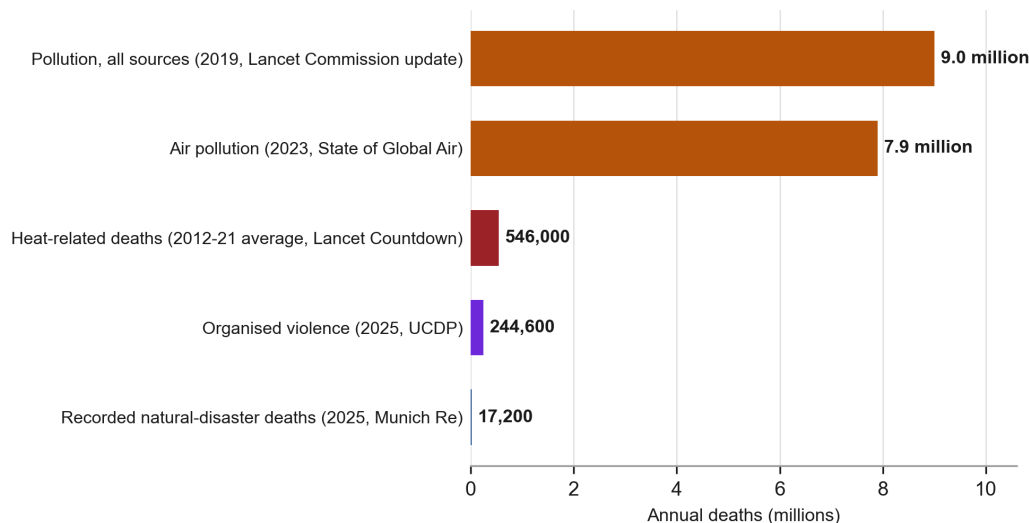


Figure 2. Pollution is the largest of the measured mortality burdens. Annual deaths associated with each stressor, latest available estimates (millions).

Sources: Lancet Commission update (2022); State of Global Air 2025; Lancet Countdown 2025; UCDP (2026); Munich Re (2026). Pollution and heat figures are modelled attributions; violence and disaster figures are recorded counts, so bars are indicative rather than strictly comparable.

2.3 Instability: more conflict, more fragmentation, less fiscal room

The third stressor is political and economic. The UCDP's 2025 data record [65 conflicts with state involvement, 13 of which reached the threshold of war \(1,000 or more battle-related deaths\), and about 244,600 deaths from organised violence](#) — the second most violent year since the 1994 Rwandan genocide. Interstate conflicts doubled for the second consecutive year, to eight. The consequences spill outward through energy, food and fertiliser markets, displacement, and public finances. The Internal Displacement Monitoring Centre reports that

in 2025 [conflict and violence caused more new internal displacements \(32.3 million\) than disasters \(29.9 million\) for the first time](#), and that more than 82 million people were living in internal displacement at the end of the year.

The fiscal dimension is acute. UNCTAD's [A World of Debt](#) reports that developing countries paid US\$921 billion in net interest on public debt in 2024, that a record 61 countries spent 10 per cent or more of government revenue on interest, and that 3.4 billion people live in countries that spend more on interest than on health or education. Meanwhile, geoeconomic competition has displaced environmental risk at the top of the short-term worry list: the [Global Risks Report 2026](#) ranks geoeconomic confrontation first for the two-year horizon, while extreme weather, biodiversity loss and critical change to Earth systems top the ten-year horizon. The 2026 disruption to shipping through the Strait of Hormuz, and the associated energy-price shock that the IMF flagged in its April 2026 forecasts, is a live illustration of how an instability shock transmits into import-dependent economies, food prices and fiscal balances.

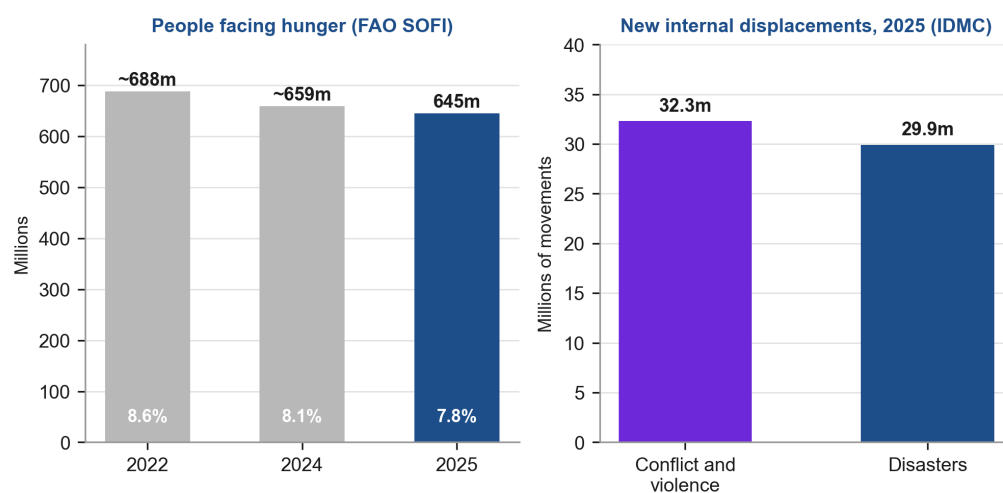


Figure 3. Hunger is edging down but remains high, and conflict has overtaken disasters as the leading cause of new internal displacement. Left: people facing hunger. Right: new internal displacements in 2025.

Sources: FAO et al., State of Food Security and Nutrition in the World 2026 (2022 and 2024 values derived from the reported changes of 43 million and 14 million relative to 2025); IDMC Global Report on Internal Displacement 2026.

2.4 The planetary context

These three pressures sit within a broader erosion of the Earth system's capacity to absorb human impact. The 2025 [Planetary Health Check](#) concludes that seven of the nine planetary boundaries are now transgressed, with ocean acidification the newest addition, and that all seven are trending in the wrong direction; only stratospheric ozone and aerosol loading remain in the safe zone. The framework, introduced by [Rockström and colleagues](#) and updated by Richardson and colleagues in 2023, is not a forecast of collapse but a measure of how much slack the planetary system has left. The less slack there is, the more any additional shock — a heatwave, a pollution event, a supply disruption — tips local systems over thresholds.

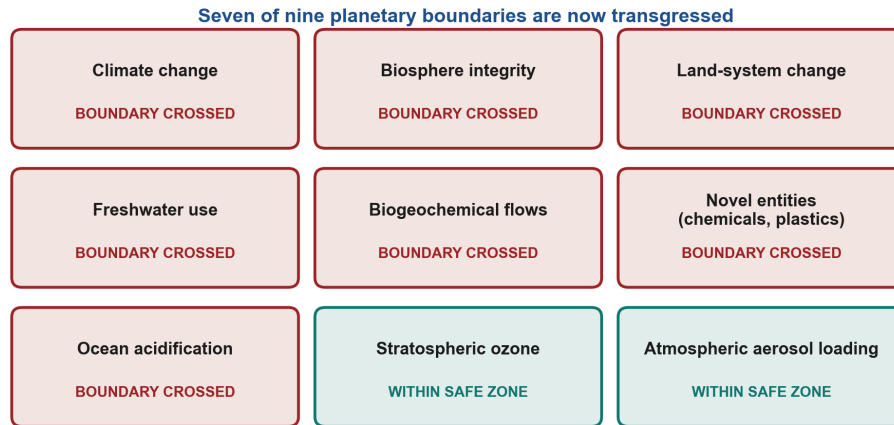


Figure 4. Seven of nine planetary boundaries are transgressed.

Source: Planetary Health Check 2025 (Potsdam Institute for Climate Impact Research and Stockholm Resilience Centre); diagram by H Heuristics.

KEY TAKEAWAY

Each stressor is large on its own. What makes the twenty-first century distinctive is that all three are intensifying together, against a background in which the Earth system itself has less slack. Strategy therefore has to be designed for the combination, not for any one of the three.

3. How Stresses Compound: From Polycrisis to Policy

A shock rarely stays where it starts. The distinguishing feature of the present era is the density of the links between systems, which allows a disturbance in one to become a crisis in another. Understanding those links is the first step to interrupting them.

The term *polycrisis* entered mainstream debate through the work of the [Cascade Institute](#), which defined it as a cluster of related global crises whose interactions produce a combined effect greater than the sum of the parts, and through the economic historian Adam Tooze's [widely read 2022 essay](#). The concept is sometimes criticised as a label rather than a theory. It becomes useful when it is broken down into specific, testable transmission channels — the routes by which stress in one domain becomes stress in another — because each channel is a point at which policy can intervene.

3.1 Six transmission channels

The evidence points to six channels that recur across regions and across the three stressors. They are summarised in Table 1 and discussed below.

Table 1. Six channels through which climate, pollution and instability compound

Channel	Mechanism	Illustrative evidence	Capacity layer that interrupts it
Food and water	Heat and drought cut yields; ozone damages crops; conflict and energy shocks raise input and transport costs	645 million people facing hunger in 2025; 2.1 billion with moderate or severe food insecurity	Sense, Distribute, Protect
Health and labour	Heat and particulates reduce hours worked, raise illness and drain health budgets	2.41 billion workers exposed to excessive heat ; 7.9 million air-pollution deaths	Protect, Buffer
Energy and supply chains	Heatwaves strain grids; fuel-import shocks raise prices; fossil dependence couples economies to geopolitics	Clean energy investment about US\$2.2 trillion against US\$1.2 trillion for fossil fuels in 2026	Distribute, Buffer
Public finance and capital	Disaster costs and interest burdens crowd out investment; risk premia rise where shocks are frequent	US\$921 billion net interest paid by developing countries in 2024	Buffer, Govern
Displacement and migration	Disasters and conflict move people into already-stressed cities and borderlands	62.2 million new internal displacements in 2025	Protect, Govern
Institutions and trust	Repeated shocks erode state capacity, public trust and cooperation, raising the odds of the next failure	Half of surveyed experts expect a turbulent or stormy world within two years	Govern and learn

Capacity layers refer to the five-layer Capacity Stack introduced in Section 4.

Food and water. Agricultural systems are exposed to all three stressors. Heat and drought lower yields directly; ground-level ozone, a product of the same emissions that warm the climate, reduces crop productivity further; and conflict and energy shocks raise the price of fertiliser, fuel and freight. The FAO-led [State of Food Security and Nutrition in the World 2026](#) reports that hunger fell for a third consecutive year, to about 645 million people (7.8 per cent of the world) in 2025, but warns that the 2026 Middle East conflict, weather extremes, and cuts to aid are threatening that progress. Africa now has more hungry people (about 309 million) than Asia (about 292 million).

Health and labour. Pollution and heat both reduce the effective workforce. They do so through acute illness and death, but also through chronic channels — impaired cognition from lead exposure, reduced lung function in children, kidney damage in heat-exposed workers — that lower lifetime productivity. These costs fall on household incomes, health budgets and employers at the same time.

Energy and supply chains. Energy is the channel through which instability most directly becomes a development shock. Economies that import most of their fuel are exposed to price spikes and supply interruptions, and economies with fragile grids are exposed to heat-driven demand peaks. The physical overlap between energy and pollution is almost complete: the same combustion that produces carbon dioxide produces fine particles. The Lancet Countdown 2025 attributes about 752,000 of India's 1.7 million PM2.5 deaths in 2022 to fossil-fuel sources, and estimates that the shift away from coal, mostly in wealthier countries, [prevented around 160,000 premature deaths a year](#) between 2010 and 2022.

Public finance and capital. Fiscal space is the capacity to respond. Where governments already spend more on interest than on health or education, a disaster forces a choice between recovery and basic services. Lenders respond to repeated shocks by raising risk premia, which makes the next round of capacity-building investment more expensive, producing a self-reinforcing loop in which the countries that most need to invest face the highest cost of doing so.

Displacement and migration. People displaced by either disasters or conflict most often remain within their own countries and concentrate in cities or camps with limited infrastructure, which raises exposure to heat, flooding and air pollution in the places that receive them. IDMC's data show 13.6 million people living in disaster-related displacement and 68.6 million in conflict-related displacement at the end of 2025.

Institutions and trust. The final channel is the slowest and the most consequential. Repeated shocks strain public administrations, erode trust, and divert attention and funds from long-term investment to emergency response. Weak institutions then handle the next shock less well. This is the channel through which a series of manageable shocks can become an unmanageable one.

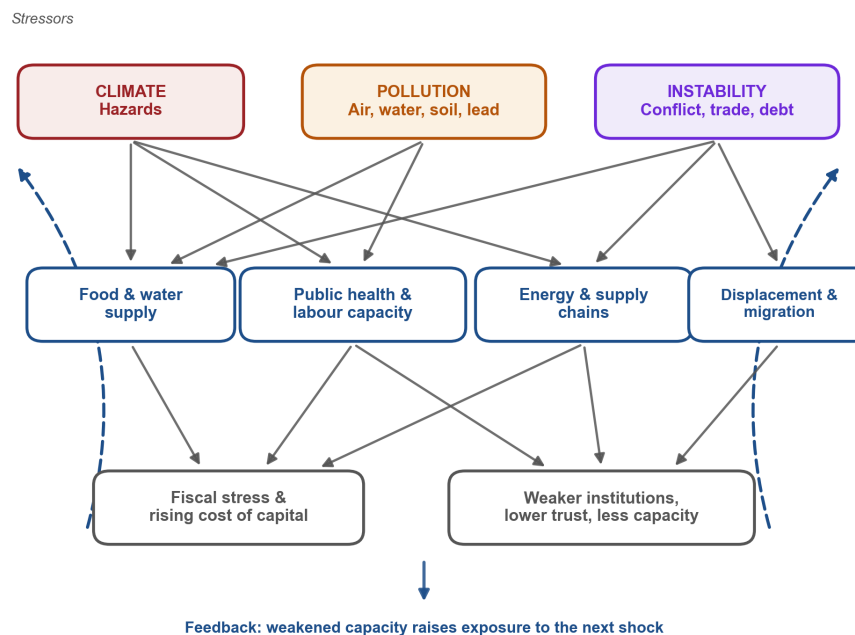


Figure 5. How the three stressors compound. Stressors (top) transmit through food, health, energy and displacement channels (middle) into fiscal stress and weaker institutions (bottom), which feed back into higher exposure to the next shock.

Source: H Heuristics conceptual framework; the diagram is schematic and not a quantified model.

3.2 The ratchet: why compound stress erodes capacity

The most important implication of this structure is that repeated shocks can ratchet a system downward. If a household sells a productive asset to cope with one drought, it enters the next with less. If a government cuts maintenance spending to fund disaster relief, its infrastructure is more vulnerable to the next storm. If a country borrows at a high rate to rebuild, it has less fiscal room when the next crisis arrives. Each shock reduces the capacity to absorb the one after it. Figure 6 illustrates the pattern: a system with high adaptive capacity dips less, recovers faster and can end each cycle better than it began, while a system with eroded capacity is pushed down by each successive event, even if each shock is individually survivable.

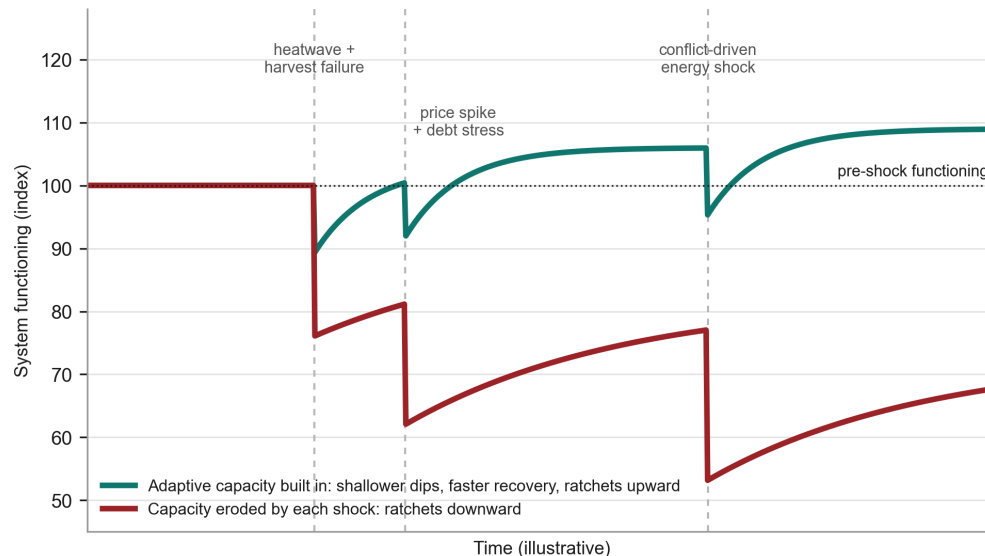


Figure 6. Capacity determines whether compound shocks ratchet a system down or build it up. Conceptual trajectories for two systems facing three overlapping shocks.

Source: H Heuristics conceptual illustration; not an empirical model. The shape follows the resilience literature on absorptive, adaptive and transformative responses.

This is why the question of *when* to build capacity matters as much as *how much*. Capacity built before the shock sits on the right-hand side of the ratchet; capacity built after the system has already been weakened must first recover the lost ground. The UN Office for Disaster Risk Reduction's [Global Assessment Report 2022](#) projects that the world is on course for about 560 disasters a year by 2030, up from a baseline of roughly 350–500 medium- to large-scale events a year, which implies that the frequency of testing is rising even as buffers thin.

3.3 Why single-threat planning fails

Planning that treats each hazard separately has three characteristic failures. It under-counts joint risks, because the probability and the impact of a combination are not the sum of their separate probabilities and impacts. It duplicates capacity, building a separate early-warning system, response team and reserve fund for each hazard when many functions could be shared. And it misses the opportunities that cut across silos, such as a clean-energy investment that cuts emissions, air pollution and import dependence at once. The remainder of this report takes the opposite approach: it identifies capacities that are valuable across the whole range of stresses.

4. Adaptive Capacity: A Working Framework

Adaptive capacity is the standing ability of a system to adjust to disturbance, moderate damage, take advantage of opportunities and cope with consequences. It is an asset, not an event, and it can be measured, invested in and depleted. This section defines it, distinguishes it from related ideas and introduces the five-layer Capacity Stack that organises the rest of the report.

4.1 Definition and four functions

The IPCC defines adaptive capacity as the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences. The resilience tradition, from C.S. Holling's early work on ecological stability to the [Stockholm Resilience Centre's synthesis of social-ecological resilience](#), adds a useful distinction between persistence (absorbing shocks and staying in the same state), adaptability (adjusting within the current state) and transformability (shifting to a different state when the current one is no longer viable). This report operationalises the concept in four functions:

- **Anticipate** — detect threats early and understand how they are likely to interact. This covers forecasting, monitoring, early warning and scenario planning.
- **Absorb** — take the hit without losing essential function. This requires buffers: money, stocks, redundancy and protective natural assets.
- **Adapt** — adjust practices, assets and institutions in response to experience. This requires flexibility, learning and the money and authority to change course.
- **Transform** — change the underlying structure when the old one cannot be sustained, for example by relocating settlements, shifting livelihoods, or replacing a fossil-fuel-dependent energy system.

These functions are sequential in time but concurrent in practice. A society should be investing in all four at once, with the mix shifting as exposure rises and options narrow.

4.2 What adaptive capacity is not

Three related concepts are sometimes conflated with adaptive capacity. *Robustness* is the ability to withstand a specific, anticipated load, such as a sea wall designed for a 100-year storm; it is valuable but brittle when the load exceeds the design. *Resilience* is often used loosely to mean any ability to bounce back, but in its narrow sense it describes the outcome of a particular shock rather than the standing capability. *Preparedness* describes readiness for a defined event. Adaptive capacity is broader than all three: it is the general-purpose ability to respond well to events that were not specifically anticipated, which is the situation compound stress creates.

Adaptive capacity also differs from *adaptation* itself. Capacity is the potential to adapt; adaptation is the action taken. A country can have substantial capacity that goes unused, and it can take adaptation actions that, if poorly designed, reduce long-term capacity. This distinction matters for measurement, as discussed in Section 14.

4.3 The Capacity Stack

The framework at the centre of this report organises adaptive capacity into five layers, each building on the one beneath it (Figure 7). The layers are defined by what they do, not by the sector or agency that delivers them, which allows a single investment to be assessed across the whole stack.

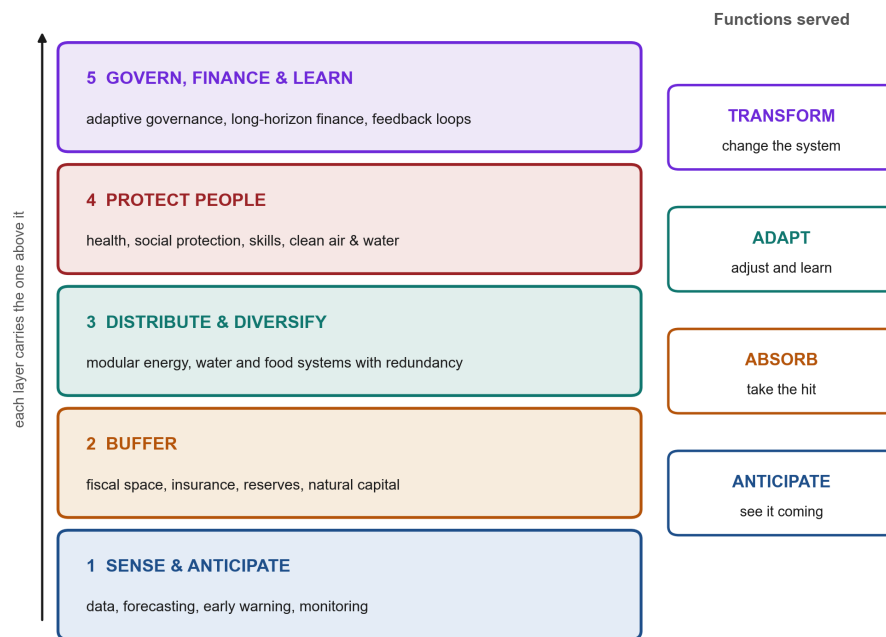


Figure 7. *The Capacity Stack. Five layers of adaptive capacity, each of which serves one or more of the four functions of anticipating, absorbing, adapting and transforming.*

Source: H Heuristics framework. The layers are cumulative: effective buffers require good sensing, and effective governance requires all four layers beneath it.

Table 2. The Capacity Stack: purpose, instruments and indicators

Layer	Purpose	Typical instruments	Indicator of progress
1. Sense and anticipate	See threats early and understand their interactions	Multi-hazard early warning; integrated hazard, air-quality and conflict monitoring; risk maps; scenario analysis	Share of population covered by actionable early warning; lead time; forecast skill
2. Buffer	Absorb a shock without losing essential function	Fiscal reserves; contingent credit; catastrophe bonds and insurance; food and fuel stocks; wetlands, mangroves, forests	Months of import cover; share of losses insured; pre-arranged finance as share of expected losses
3. Distribute and diversify	Avoid single points of failure	Distributed solar and storage; water reuse and multiple sources; diversified crops and suppliers; modular infrastructure	Share of critical services with a backup; supplier and energy-source diversity
4. Protect people	Keep people healthy, skilled and secure	Clean air and water; heat plans; clean cooking; adaptive social protection; health system readiness; education	Population coverage of social protection; exposure to unsafe air; heat-health plan coverage
5. Govern, finance and learn	Decide well, pay for it and improve	Adaptive planning; multilevel governance; long-term finance; transparent data; evaluation and review cycles	Share of plans funded; policy revision cycles; adaptation finance vs. need

Indicators are illustrative; Section 13 proposes a fuller scorecard.

4.4 Why a stack rather than a list

Many adaptation frameworks present a list of sectors — agriculture, water, health, infrastructure. The Capacity Stack differs in two ways. First, it is functional rather than sectoral. A multi-hazard early-warning system serves agriculture, health and infrastructure; a fiscal buffer serves all of them; distributed energy underpins water pumping, cold chains and clinics. Organising by function makes shared capacities visible and avoids duplication. Second, it is cumulative. Layers depend on those beneath them: a buffer is only useful if the threat is sensed early enough to deploy it, and a governance process is only as good as the data it draws on and the protections it can deliver. This implies a sequencing logic in which gaps in lower layers should generally be closed first, while recognising that all layers must be built eventually.

4.5 Measuring capacity

Measurement is imperfect, but usable proxies exist. The Notre Dame Global Adaptation Initiative's [ND-GAIN Country Index](#) scores countries on vulnerability and readiness, and it is widely used to compare national adaptive capacity. COP30 in Belém adopted a set of [59 voluntary indicators](#) to track progress on the Global Goal on Adaptation, though delegates criticised the final list as weakened and in places too vague to operationalise. Most indicators measure inputs (plans, budgets, systems in place) rather than outcomes (whether people were actually protected), and few capture compound risk. Section 13 proposes a scorecard that combines input and outcome measures, and Section 14 discusses the limits of any single metric.

KEY TAKEAWAY

Adaptive capacity is a standing asset that serves four functions — anticipate, absorb, adapt, transform — and can be organised into five cumulative layers. The framework is deliberately functional rather than sectoral, so that a single investment can be judged by how much of the stack it strengthens.

5. Layer 1 — Sense and Anticipate

Information is the cheapest form of adaptive capacity. A warning that reaches a household a day before a cyclone costs a fraction of the damage it prevents, and it works whatever else goes wrong. Sensing is therefore the first layer of the stack and the one that deserves priority where resources are scarce.

5.1 The case for early warning

The Global Commission on Adaptation's [Adapt Now](#) report estimated that just 24 hours' notice of an impending storm or heatwave can cut the resulting damage by around 30 per cent, and that an investment of US\$800 million in early-warning systems in developing countries could avoid US\$3–16 billion in losses a year. The Commission placed early warning first among five investment areas whose combined US\$1.8 trillion outlay over 2020–2030 it estimated could generate US\$7.1 trillion in net benefits. These figures are the Commission's own projections, not independently verified outcomes, and the benefit-cost ratios vary widely by context, but the direction is robust: warning systems are among the best-value public investments on record.

The WMO's [Atlas of Mortality and Economic Losses](#) shows that recorded disasters have risen sharply since 1970 while deaths per event have fallen, which the WMO attributes largely to improved early warning. The UN's [Early Warnings for All](#) initiative, launched in 2022, aims to protect every person on Earth with multi-hazard early warning by the end of 2027. WMO-reported figures indicate that about 128 countries now report multi-hazard early-warning systems, though full coverage remains a long way off, particularly in the least developed countries and small island states.

5.2 Bangladesh: the benchmark case

Bangladesh's experience with tropical cyclones is the most dramatic demonstration that sensing, backed by institutions that act on it, saves lives. The 1970 Bhola cyclone killed at least [300,000 people](#), and the 1991 cyclone about 138,000. After independence the country built a Cyclone Preparedness Programme that combines forecasting with a network of volunteers who relay warnings door to door, together with thousands of cyclone shelters and embankments. When Cyclone Sidr struck in 2007 the toll was about 3,400, and when the far more powerful Cyclone Amphan arrived in 2020, [about 2.4 million people were moved into shelters or out of its path](#) and the official death toll in Bangladesh was about a dozen. The storms were not weaker; the system was stronger.

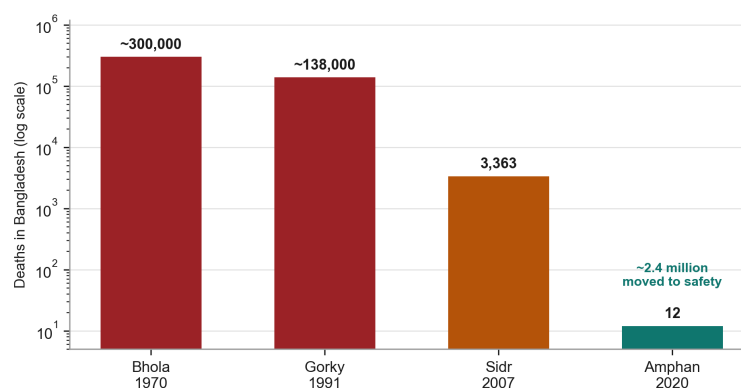


Figure 8. Cyclone deaths in Bangladesh fell by orders of magnitude as warning and shelter systems were built. Deaths from four major cyclones (logarithmic scale).

Sources: Dhaka Tribune; The Business Standard (Bangladesh); CBS News/AFP reporting on Amphan (2020). Early figures are estimates and vary by source; Amphan figure is the official Bangladesh toll.

Three features of the Bangladeshi system are transferable. It is *people-centred*: warnings are translated into instructions that households understand and trust. It is *institutional*: a standing programme with volunteers, budgets and routines, not an ad hoc response. And it is *layered*: shelters, embankments, forecasts and evacuation plans each provide a partial defence, and together they provide redundancy.

5.3 From single-hazard warning to compound-risk sensing

Most existing early-warning systems are built hazard by hazard: cyclone, flood, drought, heat. Compound stress requires something more. The first extension is to fuse hazard data with exposure and vulnerability data, so that a warning conveys not only what is coming but who will be hit hardest. The second is to integrate pollution monitoring, since air-quality emergencies — crop-residue burning, wildfire smoke, industrial releases — are predictable and cause acute health harm. The third is to build conflict and market early warning into the same systems, so that signals of disruption to fuel, fertiliser or food supply trigger pre-agreed actions before prices spike. Anticipatory action — releasing funds against a forecast trigger rather than after the damage — is spreading in the humanitarian sector.

The binding constraint is rarely technology — satellites, low-cost sensors, mobile networks and machine-learning weather models are all widening the reach of forecasts — but the last-mile link between a forecast and an action, and the institutional authority to act on it.

5.4 What to build

- **Universal multi-hazard warning with last-mile delivery.** Prioritise the least-covered countries and ensure that warnings reach people through channels they use, in languages they speak, with clear instructions.
- **Integrated risk observatories.** Combine hazard, air-quality, health, food-price and conflict data in a single dashboard at national and city level, with clear thresholds that trigger pre-agreed actions.
- **Forecast-based financing.** Link forecast triggers to pre-arranged funds so that money flows before the shock, not after.

KEY TAKEAWAY

Sensing is the cheapest layer and the foundation of the others. The Bangladesh experience shows what it takes: a forecast, a trusted last-mile channel, a shelter or other action to move to, and a standing institution to run it. Compound risk adds the need to fuse hazard, pollution and market data into one picture.

6. Layer 2 — Buffer: Fiscal Space, Insurance and Natural Capital

A buffer is whatever lets a system take a hit without losing essential function: money in reserve, insurance that pays quickly, stocks of food and fuel, and natural systems that absorb floods and heat. Buffers are the layer under greatest strain in the world's most vulnerable countries, and rebuilding them is among the highest-return investments in the stack.

6.1 Fiscal buffers and the debt constraint

A government's ability to respond to a shock depends on how much it can spend quickly. That in turn depends on its reserves, its borrowing capacity and the terms of its existing debt. UNCTAD's [A World of Debt](#) shows how thin this space has become. Developing countries paid US\$921 billion in net interest on public debt in 2024, up 10 per cent from the previous year; 61 countries devoted 10 per cent or more of revenues to interest; 3.4 billion people live in countries that spend more on interest than on either health or education; and developing countries paid roughly US\$25 billion more to external creditors than they received in new disbursements. A government in this position has little room for the counter-cyclical spending that adaptation requires.

Several instruments exist to widen the space. The IMF's [Resilience and Sustainability Trust](#) offers longer-term, lower-cost financing to support climate-resilience reforms. Climate-resilient debt clauses allow repayments to be paused when a qualifying disaster strikes; Barbados, whose Prime Minister Mia Mottley championed the [Bridgetown Initiative](#), was among the first to include them in its debt. Contingent credit lines and pre-arranged disaster finance allow governments to draw funds quickly. The new [Fund for responding to Loss and Damage](#) is intended to channel finance to the most vulnerable countries after climate-driven disasters, although its resources so far are small relative to the need.

6.2 Insurance and risk transfer

Insurance spreads the cost of a shock across space and time. Its coverage, however, is thin where it is most needed. Munich Re's data show that in 2025 [about 52 per cent of natural-disaster losses were uninsured](#), and the protection gap is far larger in low- and middle-income countries, where a small share of losses is typically insured. Sovereign risk pools, parametric insurance that pays on a measured trigger such as wind speed or rainfall rather than assessed damage, and micro-insurance for smallholders are scaling up, but all depend on affordable premiums and trusted payout mechanisms.

Insurance transfers risk but does not reduce it, and premiums can become unaffordable or coverage withdrawn as risk rises; it is one buffer among several and should be linked to risk-reducing conditions such as building standards.

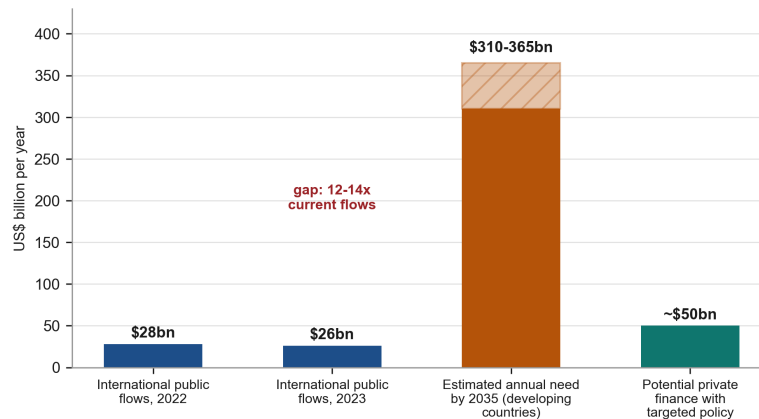


Figure 9. The adaptation finance gap. International public adaptation finance to developing countries was US\$26–28 billion a year, against estimated annual needs of US\$310–365 billion by 2035.

Source: UNEP Adaptation Gap Report 2025 (Running on Empty). Needs are 2023 values, not inflation-adjusted; private-finance potential is the report's estimate if backed by targeted policy and blended finance.

6.3 Natural capital as a buffer

Ecosystems provide some of the cheapest and most durable buffers. Mangroves, coral reefs, wetlands, floodplains and forests absorb storm surge, store floodwater, cool cities and filter pollutants. [Menéndez and colleagues](#) estimated that mangroves prevent more than US\$65 billion in flood damages a year and protect some 15 million people worldwide. The Global Commission on Adaptation named mangrove protection as one of its five high-return investment areas. These systems also tend to deliver co-benefits — fisheries, carbon storage, biodiversity, recreation — that purely engineered defences do not. They are not a substitute for engineering where exposure is extreme, but they often form the cheapest first line of defence and should be priced as infrastructure.

Such options illustrate the [triple dividend of resilience](#) described by ODI and the Global Facility for Disaster Reduction and Recovery: avoided losses when a shock occurs, economic gains from reduced risk, and co-benefits even when no shock occurs. A buffer that pays off in normal years is far easier to maintain than one that pays off only in a rare event.

6.4 Physical stocks and redundancy

The fourth form of buffer is physical: grain reserves, fuel and fertiliser stocks, spare parts, backup power for hospitals, and redundancy in transport networks. Just-in-time supply chains treat such stocks as waste; recent shocks suggest they are insurance, provided they are positioned where they can be reached when roads or ports are closed. The World Bank's [Lifelines](#) study estimates that more resilient infrastructure in low- and middle-income countries could generate US\$4.2 trillion in net benefits, or about US\$4 for every US\$1 invested, and emphasises that redundancy — multiple roads, multiple transmission lines, multiple water sources — is often cheaper than hardening any single asset.

KEY TAKEAWAY

Buffers are where compound stress bites hardest. The fiscal buffer is the most degraded, with US\$921 billion in annual net interest payments in developing countries; the financing gap for adaptation is 12–14 times current flows. Rebuilding buffers means widening fiscal space, expanding affordable insurance, investing in natural capital and holding physical stocks and redundancy where they matter.

7. Layer 3 — Distribute and Diversify: Energy, Water and Food Systems

Centralised systems are efficient in normal times and brittle in abnormal ones. A single grid, a single reservoir, a single export crop or a single supplier is a single point of failure. The third layer of the stack reduces dependence on any one source, route or node, and it is where the overlap between adaptation, mitigation and pollution control is greatest.

7.1 Energy: distributed clean power as a resilience asset

Energy is the system on which almost every other service depends, and it is the one most exposed to all three stressors. Heatwaves raise cooling demand while reducing thermal power output; storms and fires damage transmission lines; fuel-import shocks raise costs; and fossil combustion generates both emissions and air pollution. A power system built on distributed solar, storage and flexible grids has a different risk profile: its fuel is free and local, it can be built in months rather than years, and its failure modes are small and uncorrelated rather than large and systemic.

The investment trend is already running in this direction. The IEA's [World Energy Investment 2026](#) projects total energy investment of about US\$3.4 trillion in 2026, of which about US\$2.2 trillion goes to clean energy — renewables, nuclear, grids, storage, efficiency and electrification — against about US\$1.2 trillion for oil, gas and coal. Electricity-related spending now accounts for nearly 60 per cent of the total, and solar alone attracts about US\$365 billion. The IEA notes that roughly three-quarters of the 2026 investment decisions were taken before the current Middle East conflict, and that the resulting energy-security shock is likely to reshape investment further.

Pakistan offers a striking example of how fast distributed energy can scale when grid power is unreliable and expensive. According to Ember, the country [imported about 17 GW of solar panels in 2024](#), roughly double the previous year, overwhelmingly for rooftop systems purchased by households and businesses; imports from China alone rose from about 2.5 GW in 2021 to about 16.6 GW in 2024. Official installed-capacity figures are far lower than the import totals, so the imports are best read as an upper bound on deployment. The episode also exposes the other side of the coin: as wealthier customers leave the grid, the fixed costs of the system fall on those who remain, a distributional problem that policy must address.

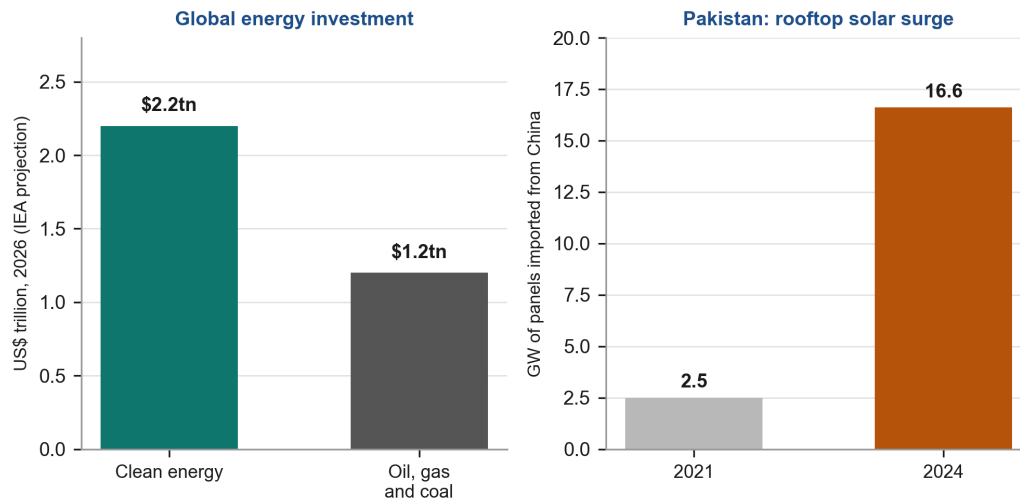


Figure 10. Clean energy now attracts almost twice the investment of fossil fuels, and distributed solar can scale very quickly. Left: global energy investment, 2026. Right: Pakistan's solar panel imports from China.

Sources: IEA World Energy Investment 2026 (projection); Renewables First analysis of Chinese export data and Ember (2025). Imports are not equivalent to installed capacity.

Distribution matters at the level of the grid too. Resilient power systems combine generation diversity, battery storage, interconnection and demand flexibility, and — for critical loads such as hospitals, water pumping and telecommunications — local backup. The World Bank and African Development Bank's [Mission 300](#) programme aims to connect 300 million Africans to electricity by 2030, with distributed solutions playing a major role; the benefit is both development and resilience, since electrified clinics, pumps and cold chains are more capable of operating through a shock.

7.2 Water: multiple sources and reuse

Water security under climate stress depends on diversification. Singapore's *[Four National Taps]* (https://dro.deakin.edu.au/articles/journal_contribution/The_four_national_taps_of_Singapore_a_holistic_approach_to_water_resources_management_from_drainage_to_drinking_water/20915230) strategy — local catchment, imported water, reclaimed water (NEWater) and desalination — turned a country with few natural water resources into one with secure supply. NEWater alone was reported in 2017 to have a production capacity able to meet around 40 per cent of demand, with a long-term goal of raising reuse further. The strategy works because each tap fails differently: drought affects catchments, politics affects imports, and energy prices affect desalination, but reclaimed water depends on none of these.

The same logic applies in cities and farming systems elsewhere: managed aquifer recharge, rainwater harvesting, drought-tolerant crops, drip irrigation and leakage reduction all lower exposure to any one source. They also reduce pollution, since treating and reusing wastewater lowers discharges into rivers. The JMP data are a reminder of the baseline challenge: [2.1 billion people still lack safely managed drinking water](#), and for them the first step is any reliable source at all.

7.3 Food: diversification and local resilience

Food systems are concentrated in ways that magnify shocks: a handful of crops supply most calories, a handful of exporters supply most traded grain, and a handful of countries supply most fertiliser inputs. Diversification takes several forms: crop and varietal diversity on farms; regional trade and storage that spread risk across agro-ecological zones; local processing and cold chains that reduce post-harvest loss; and alternative inputs such as organic and biological fertilisers that reduce dependence on imported ones. The [2026 SOFI report](#) warns that the

2026 Middle East conflict and weather extremes threaten recent progress against hunger, and the IMF has specifically flagged the price and availability of fertiliser as a food-price risk. Reducing the exposure of food production to energy and input shocks is therefore both an adaptation strategy and a security strategy.

7.4 Cooling and urban systems

Cities concentrate exposure to heat, pollution and displacement, and they concentrate the infrastructure that can reduce it. Passive cooling, reflective surfaces, urban trees and shade, district cooling, and efficient air conditioning each reduce heat risk, and several reduce air pollution and energy demand at the same time. Sponge-city measures — permeable surfaces, retention ponds, green corridors — reduce flood risk and heat together. The economic case is strengthened because these measures serve multiple functions: a street tree cools, shades, filters particulates, absorbs rain and raises property value.

7.5 Design principles for distributed systems

- **Modularity.** Prefer many small units that can fail independently to a few large ones that fail together.
- **Diversity.** Avoid dependence on a single fuel, source, supplier or route, and test the diversity under joint scenarios.
- **Redundancy where it counts.** Ensure that critical services — hospitals, water pumping, telecoms, food storage — have independent backup.
- **Equity by design.** Ensure that distributed systems do not leave poorer users carrying the fixed costs of legacy networks, and that the benefits reach households without capital.
- **Interoperability.** Standardise connections and data so that small units can be aggregated and shared.

KEY TAKEAWAY

Distributed, diversified systems are the layer where adaptation, mitigation and pollution control coincide most strongly. Clean energy investment already outpaces fossil investment almost two to one, and experience from Pakistan to Singapore shows that distributed systems can scale quickly and reduce exposure to single points of failure.

8. Layer 4 — Protect People: Health, Social Protection and Skills

Infrastructure, finance and information ultimately matter because of what they do for people. The fourth layer protects the human base of the system — health, income security and skills — and it is where investments in pollution control and heat protection pay back most directly.

8.1 Health systems that can absorb compound stress

Health systems face rising demand from every direction: heat illness, respiratory and cardiovascular disease from pollution, vector-borne disease expansion, trauma and displacement from conflict, and mental-health strain from all of them. The Lancet Countdown found that heat-related deaths now average roughly 546,000 a year; the State of Global Air attributes 7.9 million deaths to air pollution. A health system that can absorb these shocks needs climate-resilient facilities, reliable power and water supply, a trained workforce, surge capacity, and surveillance that links environmental to health data. It also needs primary care that reaches populations with the highest exposure, because the burden falls disproportionately on the elderly, children, outdoor workers and the poor.

The most cost-effective health investments are often upstream. Clean air, safe water and clean cooking reduce disease before it reaches a clinic. This is the main reason that Section 10 treats pollution control as an adaptation strategy: every death avoided and every illness prevented raises the system's capacity to handle the next shock.

8.2 Heat protection

Heat is the most direct climate-health threat and one of the most tractable. The case of Ahmedabad, India, shows what a city can do with modest resources. After a 2010 heatwave that caused an estimated 1,344 excess deaths, the city introduced one of South Asia's first heat action plans in 2013, combining early warning, public awareness, training for health workers, cool roofs, and access to water and shade. A 2018 evaluation by [Hess and colleagues](#) estimated that the plan helped avoid roughly 1,190 deaths a year in 2014–2015 compared with the baseline period. These are model-based estimates, not direct counts, and the study is a pilot evaluation, but the order of magnitude is consistent with the large body of evidence that low-cost heat protection saves lives.

Occupational heat is a second front. The ILO estimates that heat exposure at work causes about 18,970 deaths a year and 22.87 million occupational injuries. Protection requires enforceable limits, scheduled breaks, shade and water, adjusted working hours and, in some sectors, income protection for lost workdays. Because outdoor labour is concentrated in agriculture, construction and informal work, protecting workers is also a poverty and food-security measure.

8.3 Adaptive social protection

Social protection is the mechanism through which public resources reach households quickly and predictably. The ILO's [World Social Protection Report 2024–26](#) estimates that just over half of the world's population, about 52 per cent, is covered by at least one social protection benefit, which leaves some 3.8 billion people unprotected, and coverage is lowest in the countries most exposed to climate hazards. Adaptive social protection extends the basic model by making it shock-responsive: registries are built to identify vulnerable households before a shock, payment systems can scale up quickly when a forecast or disaster triggers, and benefits are paired with services — livelihoods support, financial inclusion, public works that build resilient assets.

The Ethiopian Productive Safety Net Programme offers the clearest evidence. Launched in 2005 with about 5.5 million beneficiaries, it provides cash or food in exchange for public-works labour and direct support for those who cannot work. A study by [Knippenberg and Hoddinott](#) for the International Food Policy Research Institute found that receipt of programme payments reduced the initial impact of drought on household food security by 57 per cent and eliminated the adverse effect within two years, while households without support experienced effects lasting up to four years. The finding is from a single (though careful) study, and other work notes that effects depend on predictable, timely delivery of transfers, but it illustrates the principle: predictable support before and during a shock prevents the ratchet from turning.

8.4 Skills, schooling and the human base

Human capital is the most durable form of adaptive capacity because it travels with people. Children who are healthy, fed, free of lead exposure and in school grow into adults who can adapt, relocate, retrain and innovate. The UNICEF–Pure Earth analysis of childhood lead exposure estimated that lead alone costs low- and middle-income countries close to US\$1 trillion in lost lifetime economic potential. Investments in school cooling, safe school buildings and school meals therefore belong in the adaptation portfolio.

8.5 Priorities for the protective layer

- **Clean air, clean cooking and safe water first.** These reduce the baseline burden of disease and release health-system capacity for shocks.
- **Heat action plans for every large city, and occupational heat standards** — both low-cost and quickly implementable.
- **Shock-responsive social protection** with registries, payment systems and triggers in place before the next event.
- **Protect children's development** through lead abatement, nutrition, safe schools and continuity of schooling in crises.
- **Climate-ready health facilities** with reliable power, water and cooling, and surveillance that integrates environmental and health data.

KEY TAKEAWAY

Protecting people is where adaptation and public health meet. The evidence from Ahmedabad and Ethiopia shows that relatively low-cost measures — a heat plan, a predictable transfer — can substantially blunt the impact of a shock. Upstream investments in clean air and clean cooking prevent illness at its source and free up capacity for the next emergency.

9. Layer 5 — Govern, Finance and Learn

The fifth layer is what makes the other four work and last. It covers how decisions are made under uncertainty, how capacity is financed over decades, and how systems learn from experience. It is the layer most often neglected, because its outputs — good decisions, sustained funding, institutional memory — are less visible than assets.

9.1 Deciding under deep uncertainty

Compound stress makes forecasting harder, not easier. The interaction of climate, pollution and political shocks is not well described by a single best-guess scenario. The field of *decision making under deep uncertainty* has developed methods for this situation, summarised in [Marchau and colleagues' open-access volume](#). Rather than choosing the strategy that is optimal in one forecast, these methods look for strategies that perform acceptably across a wide range of futures, identify the conditions under which a strategy would fail, and build in the flexibility to adjust. A key tool is [dynamic adaptive policy pathways](#), developed by Haasnoot and colleagues, which maps sequences of actions and the signposts that would trigger a switch from one to another. The Netherlands' [Delta Programme](#) applies this logic to flood protection over a century-long horizon.

The practical lesson is to favour *no-regret* and *low-regret* options (those that pay off under almost any scenario), to keep options open where lock-in would be costly, and to schedule explicit reviews. Figure 11 illustrates, using an illustrative scoring, how different strategies perform across four contrasting futures. Strategies that strengthen sensing, buffers and distributed systems score well across the board; single-hazard or hard-defence-only strategies are more sensitive to which future arrives.

	Rapid decarbonisation	Warming overshoots 2°C+	Severe energy/ trade shock	Fiscal crisis, weak aid
Early warning and forecasting	strong	strong	strong	good
Fiscal and insurance buffers	good	strong	strong	good
Distributed solar + storage + grids	strong	strong	strong	good
Clean-air and clean-cooking programmes	strong	strong	good	strong
Adaptive social protection	good	strong	strong	good
Water reuse and efficiency	good	strong	good	strong
Hard-engineered defences only	conditional	good	conditional	weak
Single-hazard plans	conditional	conditional	weak	conditional

Figure 11. Some strategies perform well in every scenario. Illustrative robustness scoring of eight strategies across four contrasting futures.

Source: H Heuristics illustrative qualitative assessment, in the spirit of robust decision making. Scores are judgemental, not modelled outputs.

9.2 Multilevel and polycentric governance

No single level of government holds all the relevant powers. National governments set fiscal and regulatory frameworks; cities and provinces manage land use, water, transport, health delivery and emergency response; communities hold local knowledge and often the first response capacity. Elinor Ostrom's work on polycentric

governance suggests that overlapping centres of decision-making can be more resilient than hierarchical ones if they are coordinated and accountable; for adaptation this implies devolving funds and authority to where action takes place while maintaining national standards and data systems. 172 countries now have at least one national adaptation policy, strategy or plan, according to the [UNEP Adaptation Gap Report 2025](#); the challenge is moving from plans to funded implementation, especially at the local level.

9.3 Financing capacity over decades

Capacity-building requires finance on a scale and with a pattern that the current system does not deliver. The UNEP report estimates that developing countries will need about US\$310 billion a year (up to US\$365 billion on one measure) for adaptation by 2035, against international public flows of about US\$26 billion in 2023, down from US\$28 billion the year before, leaving a gap of 12 to 14 times current flows. At COP29, parties agreed a new collective climate finance goal of at least US\$300 billion a year by 2035. At COP30 in Belém, negotiators called for adaptation finance to rise threefold by 2035, though as one assessment notes this is a political signal rather than a binding commitment and the baseline is disputed, and endorsed a [Baku to Belém Roadmap](#) towards US\$1.3 trillion a year in climate finance for developing countries.

Closing the gap requires more than larger pledges. Four shifts are needed. First, **more concessional and grant finance** for adaptation in countries where projects cannot generate cash flows and debt is already unsustainable. Second, **lower cost of capital**, through multilateral development bank reform, guarantees, first-loss tranches and currency-risk instruments that make resilient investments bankable. Third, **bundling and blending**, so that adaptation benefits are captured in the business case for infrastructure, energy and agriculture projects rather than financed separately; UNEP estimates that the private sector could provide around US\$50 billion a year if backed by targeted policy. Fourth, **domestic resource mobilisation and budget integration**: adaptation should be built into national and local budgets, procurement rules and building codes, not left to project cycles.

A final financial principle is to value capacity at its full risk-reduction return across the portfolio of shocks it addresses. An early-warning system that protects against cyclones, floods and heat should not be judged only on the cyclone benefit. The triple-dividend framing — avoided losses, economic gains and co-benefits — is a better guide to the true return than a single-hazard benefit-cost ratio.

9.4 Learning systems

The final component is learning. Adaptation that is not evaluated is adaptation that cannot improve. This requires clear outcome indicators, independent evaluation, public data, and institutional routines that translate findings into revised plans. It also requires protection against *maladaptation*: actions that reduce vulnerability in the short term but increase it over the long term, such as sea walls that encourage development in flood-prone areas, or air-conditioning powered by coal. Section 14 discusses maladaptation in more detail.

KEY TAKEAWAY

Governance, finance and learning determine whether the other layers are built, sustained and improved. Deciding under deep uncertainty, funding at the right scale and cost, and evaluating outcomes are the core tasks. Strategies that perform across scenarios are the right default.

10. Pollution Control as Adaptation Strategy

Pollution control is usually filed under environmental protection or climate mitigation. This section argues that it belongs equally under adaptation. Clean air, clean water and clean energy raise human health, productivity and fiscal strength — the very attributes that determine how well a society absorbs shocks — and they are among the few investments that pay for themselves quickly and visibly.

10.1 Why pollution control builds adaptive capacity

Three mechanisms connect pollution control to adaptive capacity. The first is *health*. A population with lower chronic disease burden is more resilient to heat, infectious disease and displacement, and a health system with lower baseline demand has more surge capacity. The second is *productivity and human capital*: children with lower lead and particulate exposure learn more and earn more, and workers lose fewer days to illness. The World Bank estimates the health damage from PM2.5 alone at [US\\$8.1 trillion, or 6.1 per cent of global GDP](#), in 2019 — a measure of the output that clean air could unlock. The third is *fiscal and energy security*. Many pollution-control measures — shifting from coal and diesel to electricity from renewables, improving efficiency, capturing methane — also reduce fuel imports and exposure to price shocks, and so strengthen the buffer and distribution layers directly.

Pollution control also tends to be a co-benefit-rich investment. Measures that reduce combustion cut carbon dioxide, particulates and often noise and congestion together. The overlap is large enough that a single policy can be justified on health grounds alone, with climate benefits as a bonus, which makes it more politically durable than a measure justified on a distant climate benefit.

10.2 Evidence that pollution can be cut fast

The historical record shows that determined action can reduce pollution quickly and at manageable cost. Four examples are instructive.

Beijing. In 2013, Beijing's annual mean PM2.5 concentration was nearly 90 micrograms per cubic metre. Under the Air Pollution Prevention and Control Action Plan and its successors, the city restricted coal use, tightened vehicle and industrial standards and shifted heating to gas and electricity. Official figures show the annual mean fell to [about 58 in 2017, 42 in 2019 and 30.5 in 2024](#), a reduction of roughly two-thirds, and the coal share of local PM2.5 sources fell from about 22 per cent to about 3 per cent between 2013 and 2017. Beijing now meets China's national annual standard of 35 micrograms. It remains several times above the WHO's 2021 guideline of 5, so the achievement is a large improvement, not the end of the problem. The University of Chicago's [Air Quality Life Index](#) documents that China as a whole cut particulate pollution by roughly two-fifths over the same period.

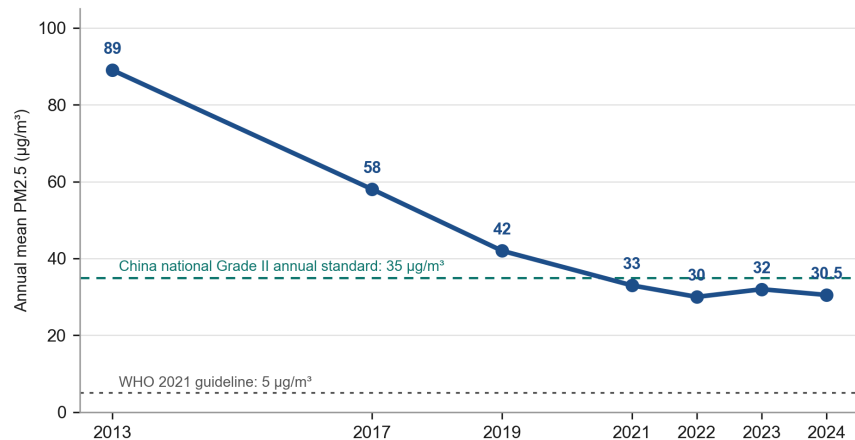


Figure 12. Beijing cut PM2.5 by roughly two-thirds in a decade. Annual mean PM2.5, selected years (µg/m³).

Sources: Beijing Municipal Ecology and Environment Bureau, as reported by the Beijing municipal government, China Daily and Xinhua; 2013 value is approximate (about 89–90). Only years confirmed in official reporting are plotted.

Leaded petrol. In August 2021, UNEP announced that [leaded petrol had been eliminated worldwide](#) when Algeria sold the last of its stocks. UNEP estimated that the phase-out prevents about 1.2 million premature deaths a year and saves some US\$2.4 trillion annually, based on an earlier academic study, and credits a two-decade campaign run through the Partnership for Clean Fuels and Vehicles. It is a rare example of a global toxic exposure being closed off entirely, and it shows that coordinated action across rich and poor countries is feasible. The remaining lead problem — informal battery recycling, contaminated soils, paint and spices — is the unfinished business [documented by UNICEF and Pure Earth](#).

The ozone layer. The Montreal Protocol phased out about 99 per cent of ozone-depleting substances, and the [2022 scientific assessment](#) projected that the ozone layer will recover to 1980 levels around 2040 over most of the world and by the mid-2060s over Antarctica. The 2016 Kigali Amendment, which phases down hydrofluorocarbons, is expected to avoid a few tenths of a degree of warming by 2100. The Planetary Health Check lists stratospheric ozone as one of the two boundaries still within the safe zone. The case is a reminder that global environmental institutions can work when they pair clear targets with funding and technology transfer.

Methane. The UN Environment Programme and the Climate and Clean Air Coalition's [Global Methane Assessment](#) found that reducing human-caused methane emissions by up to 45 per cent this decade would avoid roughly 0.3°C of warming by the 2040s and prevent about 255,000 premature deaths a year from ozone exposure, along with large crop losses and lost working hours. A later assessment, the 2025 Global Methane Status Report, concluded that more than 180,000 premature deaths a year could be averted by 2030 with existing tools; the baselines differ, but the message is consistent. The [Global Methane Pledge](#) provides a coordination framework.

10.3 A co-benefit map

Table 3. Pollution-control measures and their adaptation co-benefits

Measure	Pollution benefit	Climate / adaptation co-benefit	Capacity layer
Shift power from coal and diesel to solar, wind and storage	Cuts PM2.5, SO ₂ and NO _x ; Lancet Countdown credits coal displacement with about 160,000 avoided deaths a year (2010–22)	Cuts emissions; reduces fuel-import exposure; distributed systems fail gently	Distribute, Buffer
Clean cooking (LPG, electric, improved biomass)	Reduces household air pollution; about 2.1 billion people still lack access	Reduces deforestation and black carbon; frees time, especially for women	Protect
Methane control (oil and gas, waste, agriculture)	Reduces ground-level ozone; about 180,000–255,000 premature deaths avoidable annually by 2030	Large near-term warming reduction; fewer crop losses and heat-lost workdays	Protect, Sense
Lead abatement and safe battery recycling	Protects up to 800 million children from blood lead at or above 5 µg/dL	Raises human capital and productivity; lowers lifetime health costs	Protect
Urban transport electrification and public transit	Cuts roadside PM2.5, NO ₂ and noise	Cuts emissions and oil imports; reduces heat from combustion	Distribute
Wastewater treatment and reuse	Cuts river and coastal contamination; reduces disease	Adds drought-proof water supply (as in Singapore's NEWater)	Distribute, Buffer
Agricultural residue and wildfire smoke management	Reduces seasonal particulate peaks	Reduces fire risk; protects soil carbon and yields	Sense, Protect

Figures are drawn from the sources cited in the text; ranges reflect different assessments with different baselines.

10.4 Unfinished business and trade-offs

Not all pollution control is straightforward. The global plastics treaty is a cautionary example. Negotiations at the UN in Geneva in August 2025 ended without the agreement that delegates had been seeking, with deep divisions over whether to cap plastic production or concentrate on waste management, and over finance. A renewed process was under way in 2026, but at the time of writing no treaty text had been agreed. Novel entities — plastics, synthetic chemicals and others — form one of the seven planetary boundaries now transgressed, so the stakes are substantial.

There are also scientific trade-offs. Some air pollutants, notably sulphate aerosols, reflect sunlight and mask part of the warming caused by greenhouse gases; cutting them improves health but unmasks some warming in the short term. This is not an argument for tolerating dirty air — the health burden is far too high — but it does mean that air-quality improvements should be accompanied by faster cuts in carbon dioxide and methane. Finally, enforcement matters: the gap between rules and compliance is often what separates success from failure, and it is an institutional problem that belongs in the governance layer.

KEY TAKEAWAY

Pollution control is adaptation. Beijing, the leaded-petrol phase-out and the Montreal Protocol show that large reductions in exposure can be achieved within a decade or two, and the measures that cut pollution most also tend to strengthen energy security, health and household budgets. Reframing pollution control as capacity-building widens the coalition that supports it.

11. Building Capacity Under Instability

Conflict, geoeconomic fragmentation and financial stress differ from weather in a critical respect: they are made by people, can change direction suddenly, and often strike hardest where climate and pollution burdens are already heaviest. Capacity designed only for the weather will fail under political shocks; capacity designed for instability will usually perform well under both.

11.1 What instability does to capacity

Instability attacks adaptive capacity in four ways. It *destroys assets* — power plants, water systems, clinics, bridges — and the human capital that operates them. It *diverts resources*, as budgets shift from adaptation and development to security and relief. It *disrupts trade and supply*, raising the cost of food, fuel and inputs. And it *weakens institutions*, making coordinated action harder. The evidence from the UCDP — 65 state-involved conflicts in 2025, of which 13 were wars — and from IDMC — more than 82 million people living in internal displacement — suggests that these effects are widespread. The Russia–Ukraine war alone accounted for about 62 per cent of global battle-related deaths in 2025.

The overlap between fragility and climate exposure is large. Many of the countries with the highest climate vulnerability are also conflict-affected, with low fiscal capacity and limited access to international finance. They are also those in which aid cuts bite hardest: the 2026 SOFI report explicitly cites reductions in official development assistance and humanitarian funding as a threat to progress against hunger. Adaptation finance, which already reaches fragile states at a low rate per capita, is therefore least available where it is most needed.

11.2 Geoeconomic shocks: energy, food and finance

The most common way for instability to reach distant populations is through markets. The 2026 disruption to shipping through the Strait of Hormuz offers an example. According to market reporting in early October 2026, transits through the strait remained far below pre-crisis levels and Brent crude was trading above US\$100 a barrel. The [IMF's April 2026 forecasts](#) cut global growth to 3.1 per cent from 3.3 per cent and warned of risks to food prices if fertiliser supplies were not restored, with energy-importing developing economies most exposed. These conditions are volatile and will have changed by the time this report is read; the point is structural. Economies that depend on imported fuel and fertiliser, finance themselves in foreign currency, and have thin reserves are exposed to events they cannot influence.

The response that follows from the Capacity Stack is to reduce the exposure rather than to forecast the shock. Distributed renewable energy and efficiency reduce fuel-import dependence (Layer 3). Strategic stocks and flexible trade arrangements buffer against supply interruptions (Layer 2). Social protection that can scale quickly shields households from price spikes (Layer 4). Anticipatory finance and swap lines provide liquidity in a crisis (Layer 2). Each of these also serves the climate and pollution agendas.

11.3 Conflict-sensitive adaptation

Adaptation in fragile and conflict-affected settings requires specific adjustments. Programmes should be designed on the principle of *do no harm*: infrastructure and aid can become targets, sources of grievance or tools of control if allocated unfairly. Local institutions, including community groups, traditional authorities and municipalities, often remain functional when national institutions are not, and they should be partners rather than beneficiaries. Modular, low-cost, decentralised systems — solar mini-grids, community water points, mobile-based payments — are easier to maintain and harder to disable than centralised ones. And the humanitarian–

development–peace nexus matters: short-term relief should be designed to leave behind capacity, such as cash-transfer registries and early-warning networks, rather than only to meet immediate need.

11.4 Displacement as a capacity test

Displacement is both a symptom and a transmission channel. IDMC data show that people living in displacement at the end of 2025 included about 13.6 million displaced by disasters and 68.6 million by conflict and violence, and that new displacements are now more often the result of conflict than disaster. Host communities, often poor and already exposed, are asked to absorb large numbers at short notice. Capacity here means advance planning: land and services for expected arrivals, portable social protection and identification, and inclusion of displaced people in national systems rather than parallel ones. The IDMC data also show how quickly displacement can shrink when conditions allow return; in 2025 returns in parts of Sudan, the Democratic Republic of the Congo and Syria contributed to the first decline in internal displacement in a decade, though data gaps may account for some of the fall.

11.5 Principles for capacity under instability

- **Reduce dependence rather than predict shocks.** Diversify fuel, food and input sources, and shorten critical supply chains.
- **Build in modularity and local control.** Decentralised systems degrade gracefully and can be maintained when central institutions are weak.
- **Keep money flexible.** Pre-arranged, rapidly disbursable finance outperforms project finance in a crisis.
- **Protect the human base first.** Health, nutrition, schooling and income support are the hardest assets to rebuild and the most valuable.
- **Plan for reduced external support.** Design systems that can run on domestic resources and local skills if donor funding or trade partners fall away.

KEY TAKEAWAY

Instability is the stressor least amenable to forecasting, which makes exposure-reduction the right response. Distributed energy, diversified supply, flexible finance and local institutions each reduce vulnerability to political shocks as well as to weather, and each is already supported by the climate and pollution case.

12. Seven Case Studies in Capacity

Theory is cheap; results are what matter. This section reviews seven cases in which societies built capacity, in different hazard settings and at different income levels, and draws out what they have in common. The cases span all five layers of the Capacity Stack.

Table 4. Seven cases mapped to the Capacity Stack

Case	Stress addressed	What was built	Reported result	Primary layer
Bangladesh cyclone programme	Tropical cyclones and storm surge	Forecasting, volunteer-based warning, shelters, embankments	Deaths fell from about 300,000 (1970) to about 12 (2020, official) with about 2.4 million moved to safety	Sense
Ahmedabad Heat Action Plan	Extreme heat	Early warning, health-worker training, cool roofs, water and shade	About 1,190 deaths a year avoided in 2014–15 (model-based estimate)	Protect
Beijing air quality	Particulate pollution	Coal restrictions, vehicle and industrial standards, clean heating	Annual PM2.5 down from about 90 to 30.5 µg/m³ , 2013–2024	Protect, Distribute
Netherlands Delta Programme	River and coastal flooding	Room for the River, adaptive pathways, standing funding	Lower flood levels at about 30–34 sites; adaptive planning to 2100	Govern
Singapore Four National Taps	Water scarcity	Catchment, imports, reuse, desalination	Diversified supply ; reuse capacity near 40% of demand (2017)	Distribute
Ethiopia PSNP	Drought and chronic food insecurity	Predictable cash/food transfers, public works	Initial drought impact on food security cut by 57%	Protect
Barbados and the Bridgetown Initiative	Hurricanes and debt vulnerability	Disaster clauses in debt; IMF resilience financing; global reform agenda	Fiscal buffer for shocks; template for others	Buffer, Govern

Results are as reported by the cited sources; designs differ and results may not transfer directly.

12.1 Bangladesh, Ahmedabad and Beijing: lessons already seen

Three cases are discussed earlier in the report. **Bangladesh** (Section 5) shows that a poor, densely populated country can cut mortality from a recurrent hazard by orders of magnitude with forecasting, volunteers, shelters and embankments maintained as a standing programme over decades. **Ahmedabad** (Section 8) combined a colour-coded alert system, health-worker training, outreach to outdoor workers and cool-roof programmes; the Hess et al. evaluation is a model-based pilot study, so its estimates are indicative, but the plan was funded, linked forecast to action and was repeatedly revised. **Beijing** (Section 10) shows that a megacity of more than 20 million people can cut particulate pollution by about two-thirds within a decade through centrally enforced coal bans, industrial controls and vehicle standards, backed by public data — with costs that were substantial and uneven, which is why equity and transition support matter.

12.2 The Netherlands: planning across centuries

After the near-flooding of the Rhine delta in 1993 and 1995, when around a quarter of a million people were evacuated, the Netherlands changed its approach from raising dikes to giving rivers more room. The Room for

the River programme implemented measures at roughly 30 to 34 locations at a cost reported at about €2.3 billion, and was embedded in the permanent [Delta Programme](#), which reviews flood risk and strategy on a six-year cycle and uses adaptive pathways to keep options open to 2100. The programme is notable for its governance rather than its engineering: a standing fund, a statutory mandate, a commissioner with authority, and routine review.

12.3 Singapore: engineering the absence of a resource

Singapore's water policy treats scarcity as a design problem: four sources — local catchment, imported water, NEWater and desalination — are managed as a portfolio, with public acceptance of recycled water built through openness and education. The lesson for resource-constrained countries is that diversified supply converts dependence on one uncertain source into a manageable risk spread across several.

12.4 Ethiopia: predictable support before the shock

The Productive Safety Net Programme shifted Ethiopia from annual emergency appeals to a scheduled, rules-based system of support for chronically food-insecure households. The programme has faced criticism over targeting, public-works quality and payment delays, and its effects vary across contexts, but the IFPRI evidence is that predictable transfers substantially reduce drought damage while public works build assets.

12.5 Barbados: finance as an adaptation tool

Small island states face disproportionate hurricane losses with limited fiscal space, and Barbados treated debt terms as part of adaptation policy. Through the [Bridgetown Initiative](#), led by Prime Minister Mia Mottley, the country pressed for reform of the international financial architecture, including pause clauses for debt service after disasters, lower-cost multilateral lending and new sources of climate finance, and it incorporated such a clause into its own debt. The example shows that for high-debt, high-hazard countries the financial terms of borrowing can matter as much as the physical works they pay for.

12.6 What the cases share

- **A standing institution with a mandate and a budget**, not a one-off project.
- **A link from information to action** — warnings that trigger shelters, forecasts that trigger payments, data that triggers plan revisions.
- **Co-benefits that sustain support**: health, water security, income, and fiscal space all strengthened as well as risk.
- **Repeated revision**. Every case was adjusted as conditions and evidence changed.
- **Local ownership**: volunteers in Bangladesh, municipal corporations in Ahmedabad, communities in Ethiopia.

KEY TAKEAWAY

Capacity is buildable at many income levels and in many settings. What distinguishes the successes is not wealth or technology but institutional continuity: a mandate, a budget, a feedback loop and local ownership, sustained for years.

13. Strategies for Each Actor and a Phased Roadmap

Capacity is built by many actors at once, and each controls different levers. This section translates the Capacity Stack into specific strategies for national governments, cities, businesses, investors, multilateral institutions and communities, and organises them into a three-phase roadmap to 2050.

13.1 Actor-by-actor strategy

Table 5. Priority strategies by actor

Actor	Highest-priority actions	Stack layers
National governments	Fund and mandate multi-hazard early warning; create a standing adaptation and resilience budget line; set clean-air and heat standards; build adaptive social protection registries; reform fuel and energy subsidies towards distributed clean power; integrate compound-risk scenarios into planning and procurement	All five
Cities and regions	Publish heat and air-quality action plans with funded triggers; adopt sponge-city and urban-cooling programmes; protect and restore floodplains, wetlands and urban trees; build local early-warning and shelter networks; ensure critical facilities have backup power and water	Sense, Distribute, Protect
Businesses	Map and stress-test supply chains against joint shocks; diversify suppliers and energy sources; protect workers from heat; invest in on-site clean power and storage; disclose climate and pollution risk consistently	Buffer, Distribute, Protect
Investors and insurers	Price joint-risk exposure; support parametric and sovereign risk-transfer products; finance distributed energy, water reuse and resilient infrastructure; link premiums to risk-reducing conditions	Buffer, Govern
Multilateral development banks and donors	Expand concessional and grant adaptation finance; add disaster-pause clauses and contingent credit as standard; reduce the cost of capital through guarantees and currency instruments; fund last-mile warning and national meteorological services	Buffer, Sense, Govern
Communities and civil society	Maintain local early-warning and volunteer networks; monitor air and water quality; hold institutions to account on plans and budgets; share local knowledge across communities	Sense, Protect, Learn

13.2 A three-phase roadmap to 2050

The sequencing logic follows the cumulative nature of the stack: build foundations in the lower layers first, scale distributed systems and protection in the middle decades, and prepare for transformation where limits are reached. Phases overlap and are not rigid, and countries at different income levels will progress at different speeds. The roadmap is a framework, not a forecast.

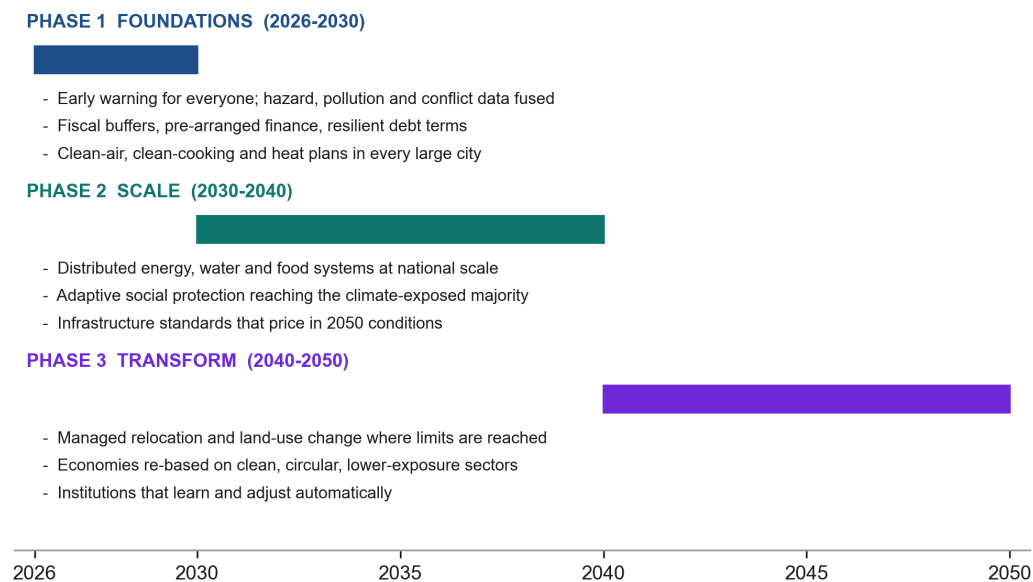


Figure 13. A three-phase roadmap for building adaptive capacity to 2050.

Source: H Heuristics framework.

Phase 1 (2026–2030): foundations. The priority is to close the cheapest and highest-return gaps. Deliver early warning to every person, in line with the 2027 Early Warnings for All target; stand up integrated risk observatories; put heat and air-quality plans in every large city; establish pre-arranged finance and resilient debt terms; and launch clean-cooking and lead-abatement programmes. Many of these measures cost little relative to their benefit and can be implemented within a budget cycle.

Phase 2 (2030–2040): scale. The priority shifts to scaling distributed energy, water and food systems to national level, expanding adaptive social protection to cover the climate-exposed majority, and embedding forward-looking standards in building codes and infrastructure procurement. Much of the infrastructure that will exist in 2050 will be built in this window, so design standards set now lock in either exposure or resilience for decades.

Phase 3 (2040–2050): transform. Where limits to adaptation are reached — coastal retreat, areas too hot for outdoor work, aquifers depleted — transformation becomes necessary: managed relocation, shifts in livelihoods, new land-use patterns, and economies rebalanced towards lower-exposure sectors. Institutions that have been learning for fifteen years will be better placed to manage this transition humanely.

13.3 A capacity scorecard

Progress should be tracked with a small set of indicators that combine inputs and outcomes. Table 6 proposes a scorecard that governments, cities or companies could adopt and adapt. It is designed to be simple enough to publish annually.

Table 6. A proposed adaptive-capacity scorecard

Layer	Indicator	Direction of progress
1. Sense	Share of population covered by actionable multi-hazard early warning; share of warnings followed by pre-agreed action	Up
2. Buffer	Months of import cover; share of disaster losses insured; pre-arranged finance as share of expected annual disaster cost; interest as share of revenue	Up, Up, Up, Down
3. Distribute	Share of critical facilities with independent backup power and water; diversity index of energy and food sources	Up
4. Protect	Share of population exposed to air above WHO guideline; coverage of shock-responsive social protection; heat-health plan coverage; children with elevated blood lead	Down, Up, Up, Down
5. Govern	Share of adaptation plans fully funded; time between plan reviews; adaptation finance relative to estimated need	Up, Down, Up

Indicators should be disaggregated by income, gender, age and location, because averages hide the most vulnerable groups.

KEY TAKEAWAY

Each actor controls different levers, but the sequencing is shared: foundations first, then scale, then transformation. The scorecard makes progress visible and keeps attention on outcomes rather than on plans.

14. Risks, Limits and the Ways Adaptation Fails

A strategy that ignores its own failure modes is not a strategy. This section sets out the main ways in which efforts to build adaptive capacity can fail, and the limits beyond which adaptation alone cannot protect people.

14.1 Hard limits and the primacy of mitigation

Adaptation has limits. The IPCC's Working Group II report found that some ecosystems and human systems are already reaching soft and hard limits, and that these limits become more common as warming rises. Heat and humidity combinations that exceed human tolerance, loss of coral reefs, ice-sheet and glacier loss, and sea-level rise that overwhelms low-lying islands cannot be adapted away. Adaptation capacity is therefore not a substitute for emissions reduction; it is a complement. The more that warming is limited, the cheaper and more feasible adaptation becomes. The [Emissions Gap Report 2025](#) shows that the world is still on course for 2.3–2.8°C, a trajectory at which many of the limits would be binding. The strategy proposed here is designed to be pursued alongside, not instead of, rapid mitigation; as Section 10 shows, many of the most effective measures do both.

14.2 Maladaptation

Maladaptation occurs when an action intended to reduce risk increases it, shifts it to others or locks in future vulnerability. Examples include sea walls that encourage building in flood-prone areas and make eventual flooding more costly; air-conditioning powered by coal, which adds to both emissions and local pollution; irrigation that depletes aquifers; and relocation that moves people from risk to poverty. Guarding against maladaptation requires attention to time horizons, distributional effects and the combined impact on all three stressors. A simple screening test is to ask of any proposed measure: does it help under all three stressors, or does it help against one while worsening another?

14.3 Inequity and who pays

Adaptive capacity is unevenly distributed, and policies can widen the gap. Private solutions such as air conditioning, rooftop solar, air purifiers and insurance are available to those who can pay; public systems must reach those who cannot. The ILO report that just over half of the world is covered by any social protection benefit, and that coverage is lowest in climate-exposed countries, is a measure of the equity challenge. Distributional design — who gets early warning, who gets the transfer, who bears the cost of the transition — should be a first-order criterion, not an afterthought. Adaptation that serves only the better-off will raise the vulnerability of the rest in relative terms and weaken the social cohesion that capacity depends on.

14.4 Measurement and evidence limits

The evidence base has gaps. Many benefit-cost ratios, including the widely quoted Global Commission on Adaptation and World Bank figures, are projections from models and assumptions and vary widely by context. Mortality attributions for pollution and heat are modelled, not counted, and are revised as methods improve — the State of Global Air 2025 revised its estimate for 2021 downward from 8.1 to 7.6 million deaths for methodological reasons. Evaluations of adaptation programmes often rely on short windows and non-random comparison groups. Indicators tend to measure inputs rather than outcomes. These limitations do not undermine the broad conclusions, which are supported by many independent lines of evidence, but they argue for humility, for continued evaluation and for avoiding false precision.

14.5 Political economy and implementation risk

Building capacity is as much a political as a technical task. Benefits are diffuse and delayed while costs are concentrated and immediate; incumbents in fossil-fuel and other legacy sectors resist change; and short electoral cycles discourage long-horizon investment. Corruption and weak procurement can drain funds. International cooperation is under strain — the failure to conclude a plastics treaty in 2025, the contested baselines for adaptation finance at COP30, and cuts to aid budgets all illustrate the point. The strategy's emphasis on no-regret, co-benefit-rich options is partly a response: measures that pay off quickly and visibly, and benefit identifiable constituencies, are likelier to survive political cycles.

14.6 Compound-risk blind spots

Finally, any framework can be overwhelmed by events it did not foresee. Compound stress is characterised by surprises and by interactions that are hard to model. The best protection is not better forecasts but design principles that perform under surprise: redundancy, modularity, slack, diversity, learning and the ability to reorganise. These principles do not eliminate risk; they reduce the chance that an unforeseen shock becomes an unrecoverable one.

KEY TAKEAWAY

Adaptation is necessary but not sufficient. It has hard limits, can fail through maladaptation and inequity, rests on an imperfect evidence base, and faces political resistance. These risks argue for pursuing it alongside mitigation, screening measures against all three stressors, and building in evaluation from the start.

15. Conclusion: An Agenda for Thriving

The twenty-first century will test societies with simultaneous pressures from a warming climate, a polluted environment and a more unstable world. The evidence reviewed here suggests that the outcome is not predetermined. Adaptive capacity can be built, it pays back, and the places that have built it have shown that compound stress can be survived and, more than that, used as an occasion to become stronger.

This report has advanced five main arguments. First, climate, pollution and instability form a single interacting system of stress, transmitted through food, health, energy, finance, displacement and institutions, and repeated shocks can ratchet systems downward. Second, adaptive capacity — the standing ability to anticipate, absorb, adapt and transform — is the right object of policy, and it can be organised into a five-layer Capacity Stack: sense, buffer, distribute, protect, and govern. Third, pollution control and clean energy are among the strongest adaptation investments, because they strengthen health, productivity and fiscal and energy security together. Fourth, capacity designed for instability — through reduced dependence, modularity, flexible finance and local control — is also capacity for climate and pollution. Fifth, the case record from Bangladesh to Barbados shows that capacity is buildable at many income levels, provided that institutions, budgets and feedback loops are sustained.

15.1 Ten commitments

The agenda can be summarised as ten commitments that governments, cities, businesses, investors and communities can adopt:

- **Warn everyone.** Deliver actionable multi-hazard early warning, with last-mile channels, to every person by 2027, and extend it to pollution and market shocks.
- **Fuse the data.** Build integrated risk observatories that combine hazard, air-quality, health, food-price and conflict information.
- **Rebuild buffers.** Widen fiscal space through resilient debt terms, contingent finance and affordable insurance, and hold physical reserves and natural buffers where they matter.
- **Distribute the system.** Prioritise distributed clean energy, diversified water sources and diverse food supply to remove single points of failure.
- **Clean the air, water and kitchen.** Treat pollution control as adaptation, beginning with clean cooking, clean power, lead abatement and methane.
- **Protect the heat-exposed.** Put heat action plans in every large city and enforce occupational heat standards.
- **Make social protection adaptive.** Build registries and payment systems that can scale before the shock.
- **Decide for uncertainty.** Prefer strategies that perform across futures and build in scheduled review.
- **Fund the gap.** Raise adaptation finance towards the US\$310–365 billion a year needed by 2035, lower the cost of capital and integrate adaptation into budgets.
- **Measure outcomes and learn.** Publish a capacity scorecard, evaluate programmes independently and revise plans on a fixed cycle.

15.2 The case for acting now

The case for early action rests on three observations. Capacity built before a shock is cheaper than capacity improvised after it, because the first requires planning and the second requires recovery from a lower base. Infrastructure and institutions built over the next fifteen years will shape exposure through mid-century; standards set now determine whether they reduce or entrench vulnerability. And many of the highest-value measures — early warning, heat plans, clean cooking, methane control — are inexpensive relative to their return and can be implemented within years.

No strategy can guarantee that compound stress will be benign. What strategy can do is shift the odds and shape the outcome: it can ensure that when the shock comes, people have warning, money, power, water, health and institutions that work. That is what thriving requires, and it is within reach.

CLOSING THOUGHT

Compound stress is a test of design, not of fate. The societies that come through it best will not be those that predicted it best, but those that built capacity early, built it for more than one stress at a time, and kept learning.

References and Further Reading

Links were checked at the time of writing. A few publishers restrict automated access; those links are to the canonical publication pages.

Climate, hazards and losses

World Meteorological Organization (2026), [State of the Global Climate 2025](#) — 2025 at about 1.43°C above pre-industrial; 2015–2025 the eleven warmest years.

UN Environment Programme (2025), [Emissions Gap Report 2025: Off Target](#) — 2.3–2.5°C with NDCs; 2.8°C on current policies.

Intergovernmental Panel on Climate Change (2022), [Sixth Assessment Report, Working Group II: Impacts, Adaptation and Vulnerability](#) — 3.3–3.6 billion people in highly vulnerable contexts; limits to adaptation.

World Meteorological Organization (2023), [Atlas of Mortality and Economic Losses from Weather, Climate and Water-related Hazards 1970–2021](#).

Munich Re (2026), natural catastrophe figures for 2025, as reported by [Clean Energy Wire](#) and [Reinsurance News](#).

UN Office for Disaster Risk Reduction (2022), [Global Assessment Report on Disaster Risk Reduction 2022](#).

Richardson, K. et al. (2023), [Earth beyond six of nine planetary boundaries](#), *Science Advances*; Potsdam Institute for Climate Impact Research and Stockholm Resilience Centre (2025), [Planetary Health Check 2025](#).

Health, heat and pollution

Health Effects Institute and IHME (2025), [State of Global Air 2025](#) — 7.9 million deaths in 2023.

WHO (2025), report on the [2025 Lancet Countdown on health and climate change](#) — heat deaths, fossil-fuel air pollution.

Fuller, R. et al. (2022), [Pollution and health: a progress update](#), *The Lancet Planetary Health* — 9 million pollution deaths in 2019.

World Bank (2022), [The Global Health Cost of PM2.5 Air Pollution: A Case for Action Beyond 2021](#).

WHO (2022), [Billions of people still breathe unhealthy air](#); WHO, [ambient air quality fact sheet](#).

UNICEF and Pure Earth (2020), [The Toxic Truth: Children's Exposure to Lead Pollution](#).

UNEP (2021), leaded petrol eliminated worldwide, reported by [Al Jazeera](#).

NOAA Chemical Sciences Laboratory and partners (2022), [Scientific Assessment of Ozone Depletion: 2022](#).

UNEP and Climate and Clean Air Coalition, [Global Methane Assessment](#); [Global Methane Pledge](#).

ILO (2024), [Ensuring safety and health at work in a changing climate](#) — 2.41 billion workers exposed to excessive heat.

Hess, J. et al. (2018), [Building resilience to climate change: pilot evaluation of the impact of India's first heat action plan on all-cause mortality](#), *Journal of Environmental and Public Health*.

WHO/UNICEF Joint Monitoring Programme (2025), [Progress on household drinking water, sanitation and hygiene 2000–2024](#).

IEA, IRENA, UNSD, World Bank and WHO (2025), [Tracking SDG 7: The Energy Progress Report](#).

University of Chicago Energy Policy Institute, [Air Quality Life Index](#); Beijing Municipal Government, [Beijing's annual average PM2.5 concentration meets standards for three consecutive years](#).

Instability, displacement and food security

Uppsala Conflict Data Program (2026), [Record number of conflicts between states](#); (2025), [Sharp increase in conflicts and wars](#).

Internal Displacement Monitoring Centre and Norwegian Refugee Council (2026), [Global Report on Internal Displacement 2026](#); [summary news release](#).

UNHCR (2026), [Global Trends report 2025](#).

FAO, IFAD, UNICEF, WFP and WHO (2026), [The State of Food Security and Nutrition in the World 2026](#); coverage by [Vatican News](#).

World Economic Forum (2026), [Global Risks Report 2026](#).

International Monetary Fund (2026), [World Economic Outlook](#), April 2026 edition.

Cascade Institute, [Global polycrisis: the causal mechanisms of crisis entanglement](#); Tooze, A. (2022), [Welcome to the world of the polycrisis](#), *Financial Times*.

Adaptation, finance and governance

UN Environment Programme (2025), [Adaptation Gap Report 2025: Running on Empty](#) — needs of US\$310–365 billion a year by 2035 against about US\$26 billion of flows in 2023.

UNU-EHS, [Five outcomes of COP30: what the Belém political package really delivered](#); UNFCCC, [COP29 new collective quantified goal decision](#).

Global Commission on Adaptation (2019), [Adapt Now: A Global Call for Leadership on Climate Resilience](#).

World Bank and GFDRR (2019), [Lifelines: The Resilient Infrastructure Opportunity](#).

Tanner, T. et al. (2015), [The Triple Dividend of Resilience](#), ODI and GFDRR.

UNCTAD (2025), [A World of Debt](#).

IMF, [Resilience and Sustainability Trust](#); [Bridgetown Initiative](#); [Fund for responding to Loss and Damage](#).

Menéndez, P. et al. (2020), [The global flood protection benefits of mangroves](#), *Scientific Reports*.

Marchau, V. et al. (eds.) (2019), [Decision Making under Deep Uncertainty](#), Springer; Haasnoot, M. et al. (2013), [Dynamic adaptive policy pathways](#), *Global Environmental Change*.

Netherlands [Delta Programme](#).

Notre Dame Global Adaptation Initiative, [ND-GAIN Country Index](#); Stockholm Resilience Centre, [What is resilience?](#).

WMO and partners, [Early Warnings for All](#).

ILO (2025), [World Social Protection Report 2024–26](#).

Knippenberg, E. and Hoddinott, J. (2017), [Shocks, social protection, and resilience: evidence from Ethiopia](#), IFPRI ESSP Working Paper 109.

Energy and infrastructure

International Energy Agency (2026), [World Energy Investment 2026](#).

Renewables First, [Chinese solar panel imports to Pakistan are soaring](#); Ember, [Global Electricity Review 2025](#).
World Bank and African Development Bank, [Mission 300: Energizing Africa](#).
Chua, K.H. et al., [The four national taps of Singapore](#).

A note on figures and estimates

Figures 1, 2, 3, 4, 8, 9, 10 and 12 plot or summarise values reported by the cited primary or authoritative secondary sources; where a value was derived (for example, the uninsured share of disaster losses in Figure 1, or the 2022 and 2024 hunger totals in Figure 3, which are calculated from changes reported in the 2026 SOFI report) the caption or source line says so. Figures 5, 6, 7, 11 and 13 are conceptual schematics or illustrative assessments prepared by H Heuristics and are not empirical models. Death and cost estimates for pollution and heat are modelled attributions and are revised as methods improve; they are not strictly comparable with recorded counts. Current-events material, including the 2026 disruption to Strait of Hormuz shipping, reflects reporting available in early October 2026 and may have changed. The report is analytical and is not investment or policy advice.