United Nations Office for Disaster Risk Reduction

GAR

Global Assessment Report on Disaster Risk Reduction

Resilience Pays: Financing and Investing for our Future

2025

United Nations

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Contents

Foreword

Disasters are a defining feature of the 21st century, and the impacts are far-reaching. Storms, fires, floods, heatwaves, and droughts have become fiercer and more frequent, exacting an ever-greater toll on communities and economies – from eroding sustainable development gains, to rendering entire regions uninsurable, and knocking chunks out of countries' GDP.

This year's Global Assessment Report on Disaster Risk Reduction examines the risks posed by disasters from now to 2050 and presents an indisputable case for action. It shows the eye-watering losses inflicted by disasters today, which hit vulnerable people the hardest. And it demonstrates that, on our current trajectory, costs will continue to mount as the climate crisis worsens. But it also illustrates that, by boosting and sustaining investment in disaster risk reduction and prevention, we can slow that trend and reap economic benefits – saving lives and livelihoods while driving growth and prosperity, to help reach our Sustainable Development Goals.

This report helps countries to anticipate vulnerabilities before disasters occur. We need a concerted global effort to ramp-up disaster risk reduction and resilience. We must ensure that every person on Earth is covered by an effective early warning system, by delivering on our Early Warnings for All initiative. To achieve this, Governments must prioritise investments in disaster risk reduction. We must urgently increase the finance available to developing countries for this purpose. This year's Fourth Financing for Development conference represents a critical opportunity to drive progress.

This report clearly shows that investing in disaster risk reduction saves money, saves lives, and lays the foundation for a safe and prosperous future for us all. I urge all leaders to heed that call.

António Guterres

United Nations Secretary-General

Preface

Disasters are happening more frequently and exacting a greater toll on communities. Loss of life, habitat, loss of infrastructure, and loss of livelihoods are eroding past development gains. In poorer nations – particularly LDCs, SIDS, and LLDCs – a single disaster event can have devastating consequences for the national economy. Even among the richest countries, we are seeing record-breaking disasters. As a result, parts of these countries are becoming uninsurable. Many countries are stuck in an unsustainable spiral of incomplete and ineffective recovery.

The Global Assessment Report on Disaster Risk Reduction 2025 (GAR 2025) delves deep into these issues. It explains current levels of disaster risks and projected risks in 2050. These trends point to a future of growing disaster costs.

However, as the Report underlines, trend is not destiny.

Systematic and greater investment in disaster risk reduction and resilience can not only arrest these trends but also reverse them. When riverbank communities have access to scientific tools for planning their land use, when they have resources for building flood protection systems, and when they have early warning systems, they not only reduce damages and losses from floods, but also create conditions for prosperity and sustainable growth in their communities.

The Report unpacks many such benefits of investing in disaster risk reduction. It also highlights many innovative and diversified approaches to investing in disaster risk reduction.

Disaster risk reduction and resilience need to underpin a reformed global financial architecture fit for the 21st century as called for at the Summit of the Future.

As we approach the Fourth Financing for Development Conference later this year, the GAR 2025 carries an important message for us all: investment in disaster risk reduction not only provides a great return on investment, it is essential for our common future.

Kamal Kishore

Special Representative of the United Nations Secretary-General for Disaster Risk Reduction, and Head of the UN Office for Disaster Risk Reduction (UNDRR)

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Executive Summary

The Global Assessment Report (GAR) 2025: Resilience Pays: Financing and Investing for our Future highlights how smarter investment can re-set the destructive cycle of disasters, debt, un-insurability and humanitarian need that threatens a climate-changed world.

The global cost of disasters is growing: The economic burden of disasters is intensifying. While the direct costs of disasters averaged USD 70–80 billion a year between 1970 and 2000, between 2001 and 2020 these annual costs grew significantly to USD 180–200 billion.

Total disaster costs are now exceeding USD 2.3 trillion annually when cascading and ecosystem impacts are included. But, just as the costs of disasters have been under-estimated, so have the benefits of investing now to reduce disaster risk. Drawing on dozens of positive examples from around the globe, it shows how effective disaster risk reduction (DRR) investment can accelerate both sustainable development and economic stability at a time when catastrophic risk is increasing globally.

Chapter 1 takes stock of global progress towards achieving the disaster risk reduction targets agreed in the Sendai Framework, and recognises that despite clear progress, particularly in areas such as reducing fatalities, more needs to be done. The "big five" disasters—earthquakes, floods, storms, droughts and heatwaves—account for over 95% of direct losses in the past two decades, many of which are preventable.

Chapter 2 explores the under-counted costs of risk, and how a globalised world accelerates risk creation, and consistently underestimates the cost of compound multi-hazard events and their ripple effects across societies and ecosystems. From destructive algae bloom events that threaten fishing and tourism in the Caribbean to the melting of the Thwaites Glacier, which threatens flood coastal infrastructure worth over USD 1.8 billion, the report makes clear that humanity is under-counting the real risk of disasters.

Chapter 3 focuses on disaster risk reduction's role as a powerful lever to accelerate sustainable development and reduce risk creation. It shows how investments in risk reduction are having cascading benefits on SDG achievement globally from enhancing food security, to improving air quality, and reducing greenhouse gas emissions. These investments benefit us all but their impact is most pronounced where need is highest. For example, GAR outlines the direct positive impacts of risk reduction on food security, health, and education outcomes. But it also highlights positive indirect impacts, such as reducing productive life years lost due to forced displacement and lowering the burden on rural women in locations where sourcing safe water for daily consumption remains a challenge.

Chapter 4 looks at DRR's amplification of positive SDG impact in economic terms, and how investing in disaster risk reduction increases development investment effectiveness in an urbanizing and climate changed world. But it underscores that even though DRR is proven to reduce losses, current efforts are insufficient. It highlights how preventing annual disaster asset losses of 314bn could reap well-being benefits of twice that amount that would benefit the poorest households most.

The under-counted cost of disasters poses a significant risk to financial systems and economic stability. Reducing this potential source of volatility benefits all countries, but especially smaller economies where double-digit GDP losses occur all too often as a result of recurrent disaster events. Actions such as democratising access to quality risk information across countries and leveraging local knowledge and new technologies, such as artificial intelligence, can help countries better learn and communicate about risk in a volatile future.

The choice ahead

Chapter 5 looks forward to how exposure and vulnerability to disasters will change in our lifetimes, at how choices made today—especially those regarding energy sourcing, land use planning and investment- will shape the future. It highlights how advances in probabilistic risk modelling can turn perceived uncertainties into probabilities, enabling enhanced analytics and more targeted risk reduction decision making.

The report highlights to urgency to act to reduce seismic risk, particularly in cities where an additional 1.2 billion people are expected to be living in cities by 2050. And it explores how climate change is increasing the likelihood of experiencing severe hazard events significantly. For example, the chance of encountering a 1-in-100-year flood during a 70-year lifespan has risen from 63% for those born in 1990 to 86% for those born in 2025. GAR 2025 makes clear the choices are stark and decisions today will decide if we bequeath a future that can be characterised as "Generation Jolt" or "Generation Regeneration."

Breaking our risk-creation addiction

Chapter 6 dives deeper into how changing investment patterns can break the current cycle of disasters that leads to increasing debt, decreasing incomes, un-insurability and recurrent humanitarian crises. Citing recent analysis that suggests that without enhanced risk reduction, climate impacts could drive global incomes could decline by 19% by 2050, the report shows how effective investment now can prevent this outcome and set a sustainable path for future generations.

To do this requires implementing data-driven disaster risk financing strategies that inter-lock tailored risk reduction, risk transfer and risk management actions. Noting that the private sector accounts for 75% of capital investment globally, GAR 2025 looks at how innovative financial tools, such as green bonds, resilience focused investment funds and public private collaboration can make resilience building a standard element in future investment.

Doing so can reduce systemic financial risks globally, potentially preventing credit rating downgrades, and escalations in borrowing costs, as well as tempering humanitarian need in higher-risk countries.

The age of un-insurability?

Building on Prime Minister of Barbados' clear warning that "what is not insurable is not investable[1]," GAR 2025 homes in on the growing challenge of providing affordable, effective insurance in a world where premiums are increasing, and most of the world lacks any form of disaster risk coverage. But it also points to the green shoots of innovation that are re-imaging and revitalize risk transfer solutions such as innovations in disaster parametric insurance and the design of social safety net and risk transfer products that include built-in risk prevention incentives for consumers to make their homes safer and more resilient before a disaster occurs.

Moving beyond respond-recover-repeat

Currently just 2% of development aid is directed towards to DRR. This is despite clear evidence that disaster risk reduction, anticipatory action and accelerated recovery are highly effective in saving lives and protecting development in the face of disasters. Investing in risk prevention and extending access affordable risk transfer solutions can reduce the vulnerability and exposure that drive humanitarian crises, saving lives and resources. GAR 2025 makes clear that DRR reduces humanitarian need not only decreasing suffering but also bringing long-lasting benefits economies and societies. It makes clear that the current respond-recover-repeat downward spiral needs to—and can—be broken.

Resilience Pays

The report concludes with a call to democratise access to risk understanding, use public financing and regulation to break the risk-creation addition, innovate to keep risk transfer and insurance sustainable, make the business case for DRR, anticipate shocks to reduce humanitarian need and leverage the multiplier effect of international financial mechanisms to accelerate investment in resilience. It underscores that resilience investment can help fast-track achievement of the SDGs even if current practices often do the opposite. By outlining opportunities for how public and private financing mechanisms can be adjusted and enhanced to support more effective resilience building at scale, GAR 2025 aims to pave the way for a more stable and prosperous future for all.

Box

The UN Global Assessment Reports have reflected and shaped innovative thinking around reducing disaster risk and building resilience since 2007.

The first full edition **GAR09, Risk and Poverty in a Changing Climate,** provided evidence that disaster risk is disproportionately concentrated in lower-income countries with weak governance and rooted in underlying drivers.

GAR11, Revealing Risk, Redefining Development, identified effective public policies to address the disaster risk–poverty nexus.

In GAR13, From Shared Risk to Shared Value: The Business Case for Disaster Risk Reduction, the focus shifted, this time from public policies and investment to the largely unexplored nexus between private investment and disaster risk.

The GAR15, Making Development Sustainable: The Future of Disaster Risk Management reflected the thinking leading up to the adoption of the Sendai Framework for Disaster Risk Reduction 2015 – 2030.

The GAR Atlas 2017: Unveiling global disaster risk, presented the output of a Global Risk Model (GRM) that estimates the disaster risk associated with different kinds of hazard faced by national economies throughout the world.

GAR 2019 moved beyond single or multiple hazard disaster risk and introduced the concept of systemic risk and systemic risk management.

GAR Special Report on Drought 2021 explored the systemic nature of drought and its impacts on achievement of the Sendai Framework for Disaster Risk Reduction, the SDGs and human and ecosystems health and wellbeing.

GAR 2022 Our World at Risk: Transforming Governance for a Resilient Future, explored how, around the world, structures are evolving to better address systemic risk and how governance systems can evolve to reflect the interconnected value of people, the planet and prosperity.

GAR Special Report 2023 Mapping Resilience for the Sustainable Development Goals showcased how to apply risk information to SDG metrics to measure resilience.

GAR Special Report 2024 Forensic insights for future resilience - Learning from past disasters, looked at present and future trends, showing how forensic analysis can enable more targeted and more effective risk reduction.

[1]Rising Insurance Costs A Threat To Barbados' Competitiveness - Foreign Affairs and Foreign Trade

The GAR2025 call to action

1 Democratize risk understanding.

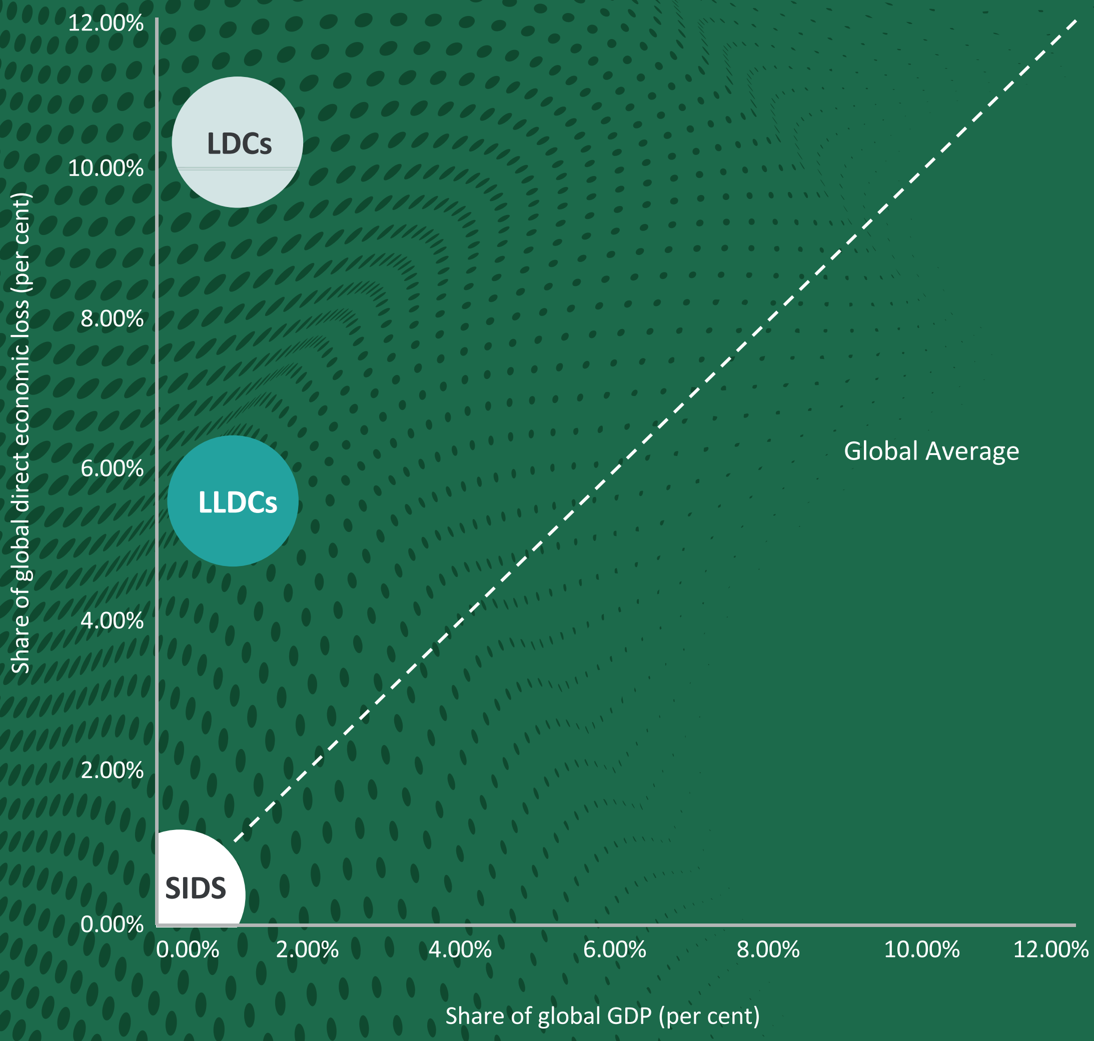
2 Use public financing and regulation to break the risk-creation addiction.

3 Innovate to keep risk transfer and insurance sustainable.

4 Make the business case.

5 Anticipate shocks to reduce humanitarian needs.

6 Leverage the multiplier effect of international financial mechanisms.



Share of global direct economic loss (per cent)
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
LDCs
LLDCs
SIDS
Global Average
0.00%
2.00%
4.00%
6.00%
8.00%
10.00%
12.00%
Share of global GDP (per cent)

CHAPTER 1

Taking stock of global progress on the Sendai Framework

Building resilience is increasingly recognized not just as a humanitarian or environmental imperative, but as a fundamental pillar of sustainable economic development. Disasters destabilize economies, strain public finances, deepen poverty and inequality and disrupt long-term development gains. As climate change accelerates and hazard profiles shift, the ability to withstand shocks—whether from floods, heatwaves, or earthquakes—is a prerequisite for achieving the Sustainable Development Goals (SDGs).

This chapter explores the current state of global disaster resilience by summarizing the progress made towards achieving the seven targets of the Sendai Framework for Disaster Risk Reduction 2015-2030[1]. Countries record their progress in an online platform, the Sendai Framework Monitor (SFM).

The SFM offers insight into how countries approach this challenge. As of October 2024, 163 countries were using the platform, up from just 88 at its launch in 2018. (Additionally, 112 countries have established national disaster loss databases, including those using the DesInventar[2] system, which helps to collect and report disaster impact data.) While gaps remain in the quality and coverage of reporting, the growing uptake signals political will and an expanding commitment to tracking resilience. Particularly valuable are Targets E and F, which measure proactive policy and cooperation frameworks, essential building blocks for a resilient future. These contrast with Targets A to D, which focus on loss and damage, and whose figures, while stark, point to where risks are not yet effectively managed.

The data also help clarify a worrying reality: the world is not on track to meet the Expected Outcome of the Sendai Framework: "The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries" by 2030. However, the figures also reveal positive trends. In some countries, disaster mortality is falling, and the number of national strategies for DRR has more than doubled. The increase in reported human impacts in recent years is partly due to improved accounting, especially for heatwaves and health effects, rather than worsening conditions.

In this context, this chapter serves a dual function. First, it provides a baseline of where countries stand in implementing the Sendai Framework. Second, it underscores a central theme of GAR 2025: that risk reduction and resilience-building are not optional add-ons to development planning—they are essential to safeguard lives, livelihoods, and long-term prosperity in an increasingly hazardous world.

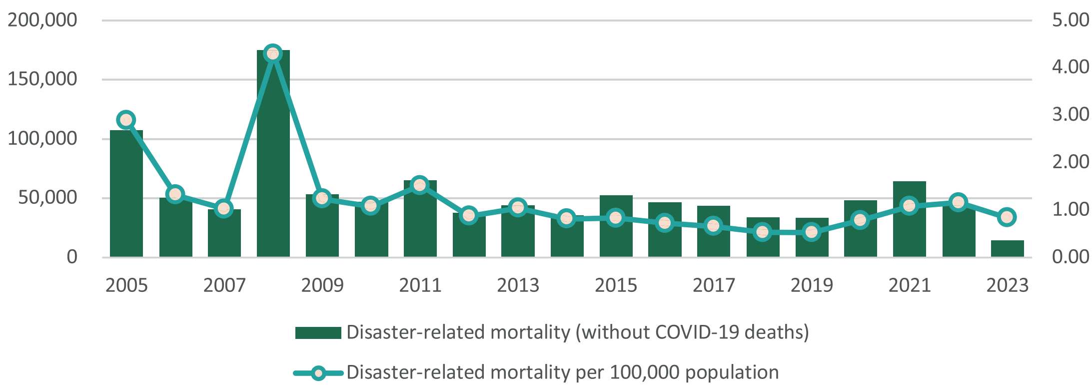
The Sendai Framework's targets collectively outline the dimensions of disaster risk to be reduced and the capacities to be strengthened. The progress achieved against these targets, based on self-reported national data submitted through the SFM, is summarized below.

Target A: Reduce global disaster mortality

One of the clearest signs that resilience-building efforts are making a difference is the drop in disaster-related deaths. Between 2015 and 2023, the average annual disaster mortality was 41,683 deaths yearly (Figure 1). While each life lost is a tragedy, the broader trend is encouraging: the global average number of disaster-related deaths and missing persons per 100,000 people has halved, from 1.61 in the decade before the Sendai Framework (2005–2014) to 0.79 in the following decade (2014–2023).

This decline points to the impact of improved early warning systems, preparedness, and risk-informed planning. More lives are saved even as the number and intensity of hazard events increase, a sign that investment in disaster risk reduction is paying off. However, this progress is not evenly distributed. Mortality rates remain high in regions with weaker infrastructure, limited access to early warnings, or where rapid urbanization has outpaced risk governance. The challenge now is to consolidate and spread these gains, ensuring that no one is left behind in disaster-prone regions.

Figure 1. **Disaster-related mortality worldwide, 2005–2023**



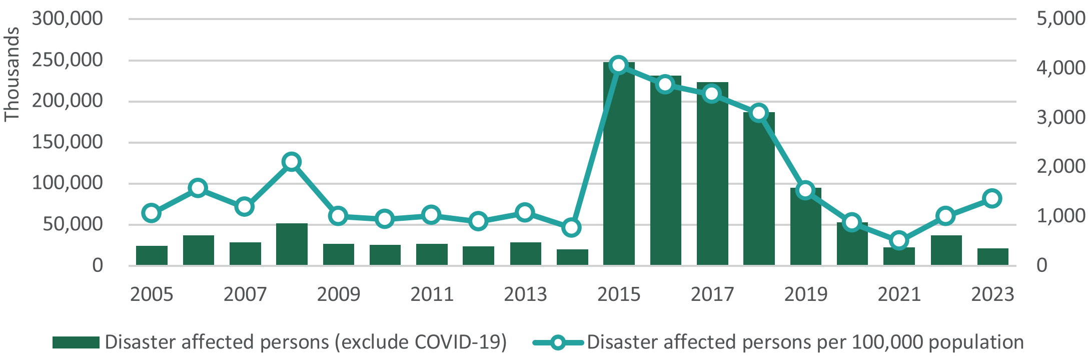
Source: UNDRR analysis and SFM (2024)

Target B: Reduce the number of disaster-affected people globally

Disasters don't just claim lives; they disrupt millions more through injury, illness, displacement, and the destruction of homes and livelihoods. On average, between 2015 and 2023, over 124 million people were affected by disasters annually (Figure 2). While the rate of people affected per 100,000 initially declined after 2015, it has started rising again in recent years—and remains higher than in the previous decade, increasing from an average of 1,158 per 100,000 in 2005–2014 to 2,028 per 100,000 in 2014–2023.

This increase reflects better reporting and shows the reality of growing exposure. As cities expand and populations rise, more people live in harm's way, often in places with limited protection against hazards. Progress under Target B depends not just on emergency response, but on how we plan our urban growth, invest in resilient infrastructure, and support vulnerable communities before disasters strike.

Figure 2. **Disaster-affected population worldwide, 2005–2023**



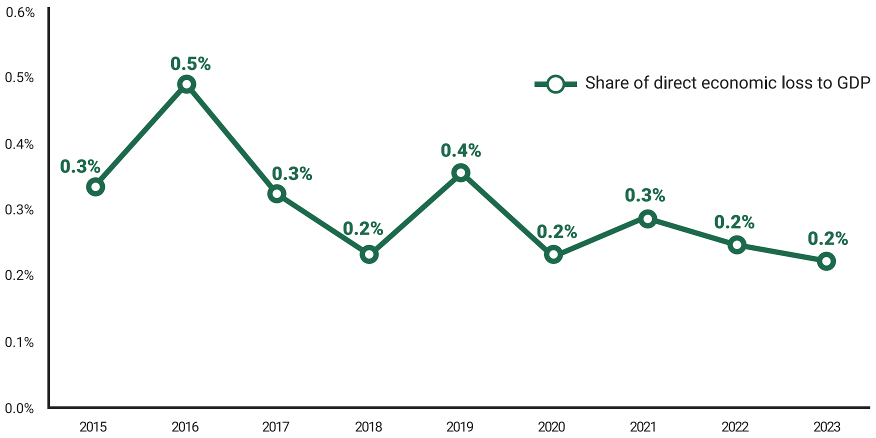
Source: UNDRR analysis and SFM (2024)

Target C: Reduce disaster-related direct economic losses

Disasters are costing the global economy dearly. Between 2015 and 2023, the direct economic losses reported through the Sendai Framework Monitor totalled at least USD 1.1 trillion, equivalent to around 0.3% of GDP for the reporting countries (Figure 3). These figures capture only part of the picture, as discussed in more detail in Chapter 2. Many countries face challenges in accurately measuring economic losses, notably cascading impacts or damage to informal economies.

Economic shocks from disasters can wipe out years of progress. They hit hardest in countries that lack strong social safety nets or access to insurance. As costs continue to rise, it is becoming increasingly clear that investments in resilience are not just a moral imperative – they're also financially sound. Target C reminds us that preventing losses is almost always more cost-effective than paying for recovery.

Figure 3. **Disaster-related direct economic losses, as officially reported by UN member states 2015–2023**



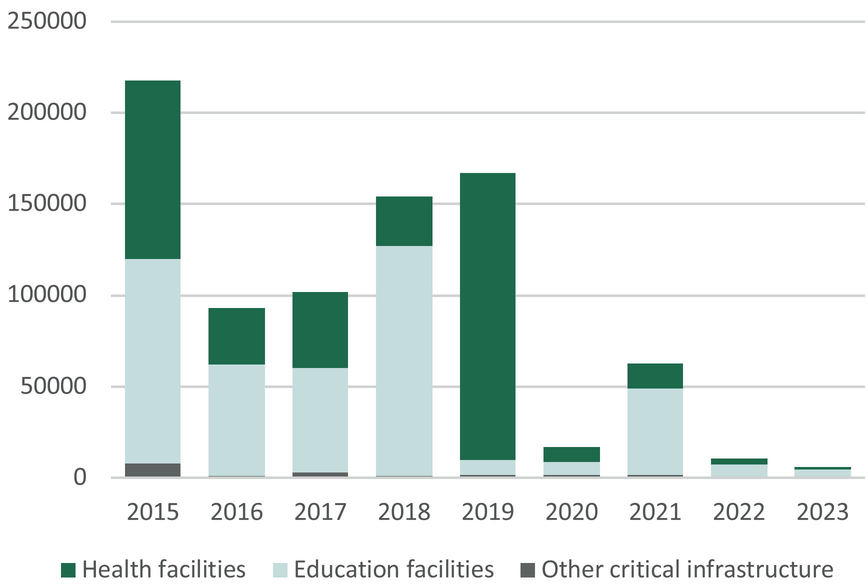
Source: UNDRR analysis and SFM (2024)

Target D: Reduce disaster-related critical infrastructure damages and basic services disruptions

When disasters hit, they don't just destroy buildings—they disrupt daily life. Between 2015 and 2023, more than 92,000 critical infrastructure units were damaged or destroyed each year (Figure 4). Over 1.6 million basic services, including education and health facilities, were disrupted annually.

The impacts go beyond the immediate. When schools are damaged, education stalls. When hospitals are offline, health crises worsen. The knock-on effects of damaged infrastructure can deepen inequality, especially in places already struggling to meet basic needs. Protecting these vital systems is central to building resilience and ensuring that disaster risk reduction pays off in everyday life.

Figure 4. **Number of damaged and destroyed critical infrastructure units, 2015–2023**



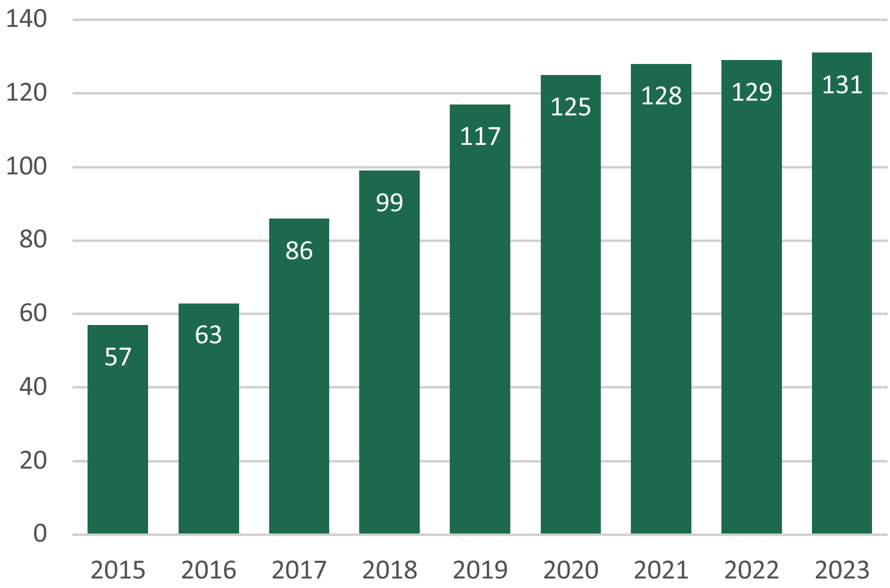
Source: UNDRR analysis and SFM (2024)

Target E: Increase national and local disaster risk reduction strategies

One of the most encouraging signs since the adoption of the Sendai Framework is the steady strengthening of disaster risk governance. The number of countries with national DRR strategies has more than doubled, from 57 in 2015 to 131 in 2023 (Figure 5). Just as importantly, the quality of these strategies is improving. The number of countries whose national DRR strategies are closely aligned with the Sendai Framework—scoring between 0.75 and 1—has quadrupled over the same period, rising from 14 to 57 (Figure 6).

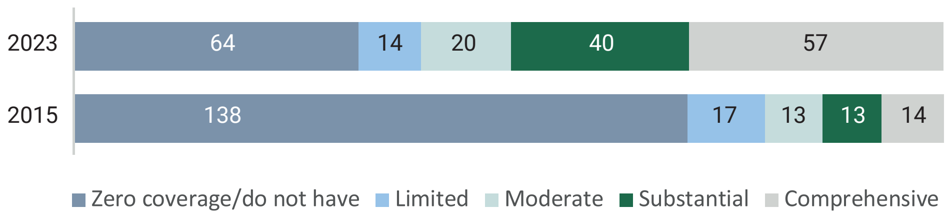
This progress reflects growing recognition that managing disaster risk requires whole-of-government and whole-of-society approaches. Support from the United Nations system has played a key role, particularly in providing technical assistance and building national capacity to design and implement robust DRR strategies. Increasingly, countries are establishing national platforms for DRR, cross-sectoral mechanisms that help coordinate action across ministries and stakeholders. These platforms have gained prominence with their inclusion as a target under the Doha Programme of Action for Least Developed Countries.

Figure 5. **Number of countries with national DRR strategies, 2015–2023**



Source: UNDRR analysis and SFM (2024)

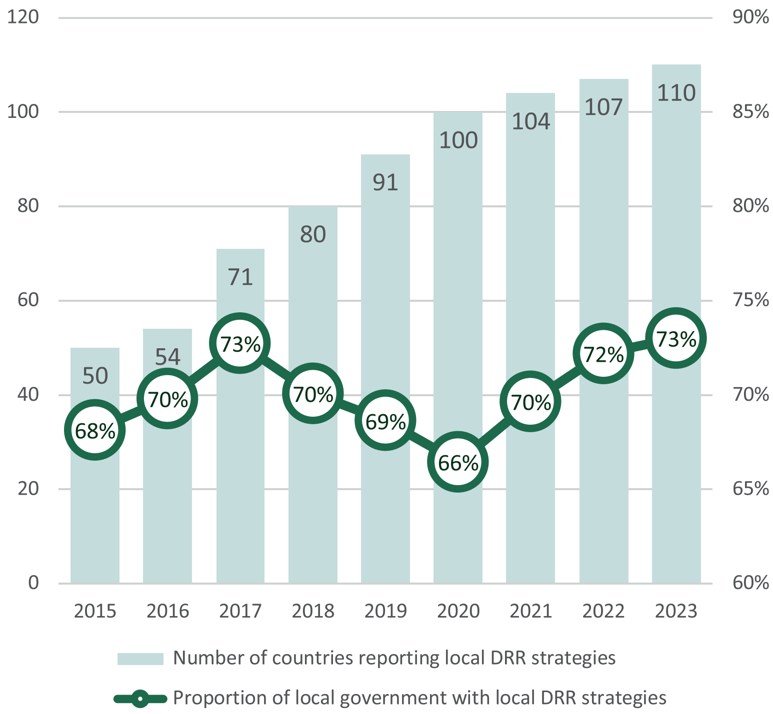
Figure 6. **Comprehensiveness of national DRR strategies, as officially reported by UN Member States**



Disaster impacts are felt first and most acutely at the local level, making local strategies just as critical. By 2023, 110 countries reported that local governments had DRR strategies, nearly double the number in 2015 (Figure 7). On average, 73% of local governments have had DRR strategies over the 2015–2023 period, though progress has varied from year to year.

Together, these national and local efforts point to a broader shift. Countries are moving beyond ad hoc responses towards more structured, risk-informed governance. Sustaining and deepening this momentum is key to turning strategies into impact on the ground.

Figure 7. **Trends in local DRR strategies**



Source: UNDRR analysis and SFM (2024)

Target F: Increase international cooperation for disaster risk reduction

Reducing disaster risk is a shared global responsibility. Target F measures how well international cooperation supports developing countries to implement the Sendai Framework. Since 2015, there has been a steady increase in international support, particularly in the form of technical assistance, training, and capacity development.

Between 2015 and 2023, the number of countries receiving such support rose from 46 to 89, with the average annual number of cooperating countries reaching 79. Much of this support has focused on enabling national institutions to develop DRR strategies, improve data systems, and enhance coordination between sectors and stakeholders.

While technical assistance has grown, financial assistance remains limited and uneven. Just 17 countries reported receiving dedicated international financial support for DRR in 2023. This figure is especially low considering the rising costs of disasters and the growing complexity of risk. Small island developing states and least developed countries, in particular, face significant resource constraints. Yet, they are often those most exposed to climate- and disaster-related shocks.

To achieve the goals of the Sendai Framework, international cooperation must go beyond short-term projects. Sustained partnerships are needed to help countries build and maintain the systems, institutions, and capacities to manage risk effectively. The gaps identified in Target F highlight the need to align development finance with disaster risk priorities and ensure that no country is left behind in the race to build resilience.

One thousand, nine hundred programmes and initiatives on science, technology and innovation transfer in disaster risk reduction were reported in the SFM. In the same period, 34,000 instances of capacity development on disaster risk reduction were reported.

Target G: Increase availability and access to early warning systems and risk information

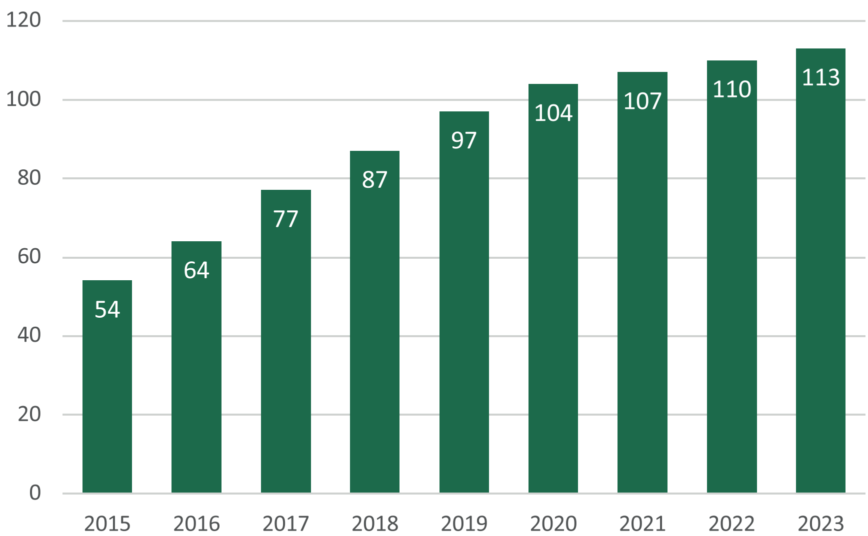
Early warning systems are among the most cost-effective ways to save lives and reduce disaster losses. Target G measures progress in ensuring that people are protected by multi-hazard early warning systems, disaster risk information and assessments. Since 2015, many countries have made significant investments in expanding early warning coverage. By 2023, 90 countries reported having multi-hazard early warning systems (Figure 8), up from 59 in 2015.[3]

However, access remains uneven. In particular, least developed countries and small island developing states continue to face serious gaps in early warning infrastructure, coverage and communication capacity (Box 1). Even where systems exist, they may not reach the most vulnerable or be trusted enough to trigger action.

Progress has also been made in risk information systems, with 103 countries reporting that they produce disaster risk information and assessments in 2023 (Figure 11). Still, the use of this information to guide decision-making remains limited in many places. Only 69 countries reported that risk information is accessible and used by people at risk.

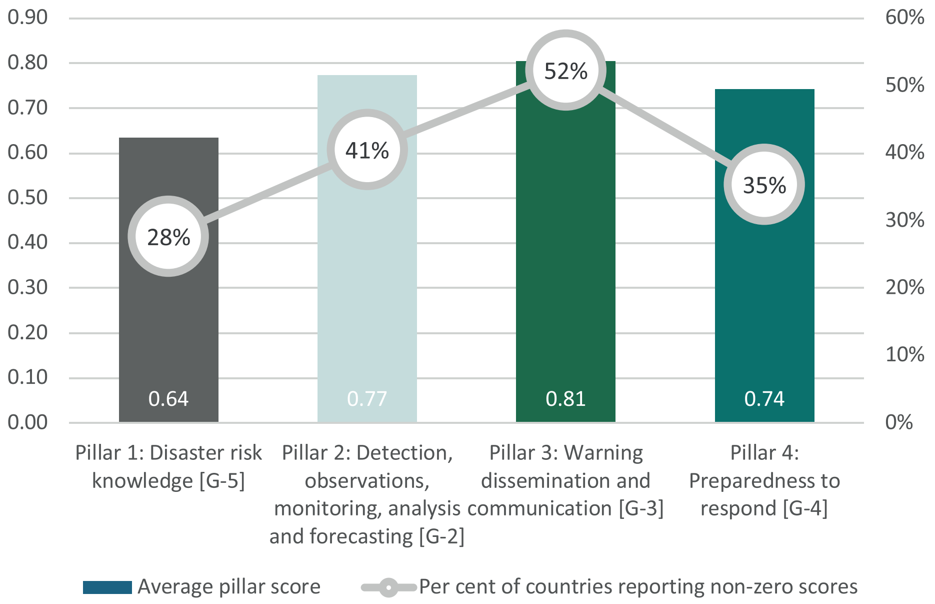
In short, the building blocks are being implemented, but the challenge now is to ensure that early warning systems are inclusive, people-centred, and actionable. This means going beyond technical capabilities to invest in outreach, education, and community engagement. It also means closing coverage gaps and ensuring that warnings lead to timely action. As hazards grow more frequent and severe, the need for universal early warning has never been more urgent or achievable.

Figure 8. **Total number of countries reporting the existence of MHEWS, 2015–2023**



Source: UNDRR analysis and SFM (2024)

Figure 9. **Status of MHEWS: Percentage of countries reporting and average score, by Early Warning for All (EW4All) pillars**



Source: UNDRR analysis and SFM (2024)

Box 1. The disproportionate cost of disasters in developing countries

Least developed countries (LDCs), landlocked developing countries (LLDCs) and small island developing states (SIDS) face steep challenges in disaster risk reduction. Despite strong political will, many struggle with limited resources and technical capacity to fully implement national and regional DRR commitments.

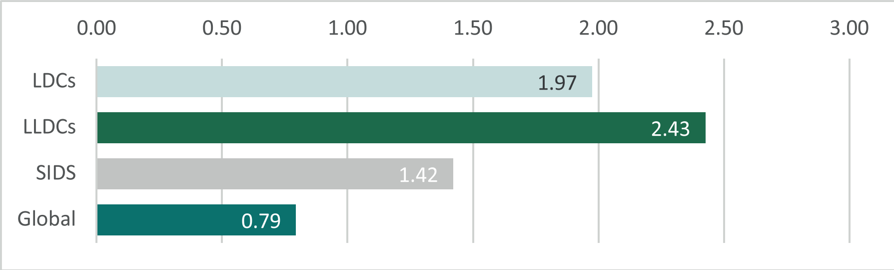
This is especially concerning given the disproportionate burden they carry. Disasters are far deadlier and more disruptive in these countries than elsewhere. Between 2014 and 2023, average annual disaster mortality rates were 1.97 per 100,000 people in LDCs and 2.43 in LLDCs, compared to a global average of just 0.79 (Figure 10). And it's not just loss of life. LLDCs report 3,126 disaster-affected people per 100,000, a 54% higher burden than the global average (Figure 11).

Economically, these countries also bear an outsized share of losses. Between 2015 and 2023, LDCs accounted for 10.4% of reported global disaster-related economic losses, despite making up only 1.06% of the total GDP of reporting countries. LLDCs reported 5.6% of losses, representing just 1.0% of global GDP (Figure 12).

At the same time, many of these high-risk countries still lack access to early warning. As of 2023, only 38% of SIDS, 63% of LLDCs, and 49% of LDCs reported having multi-hazard early warning systems in place (Figure 13).

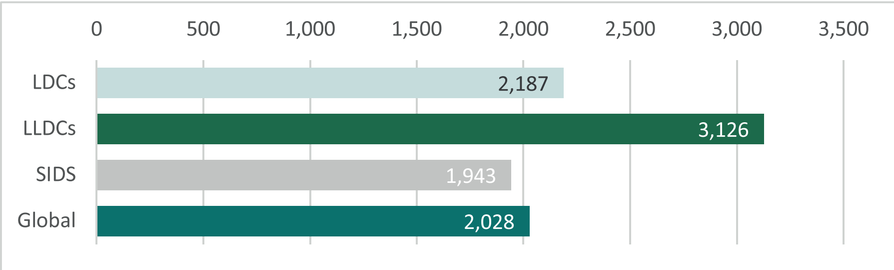
Together, these figures highlight a clear imbalance: countries most needing resilience investments are often least equipped to deliver them. Closing these gaps is essential to achieving equitable progress under the Sendai Framework.

Figure 10. Disaster-related mortality per 100,000 population, 2014–2023



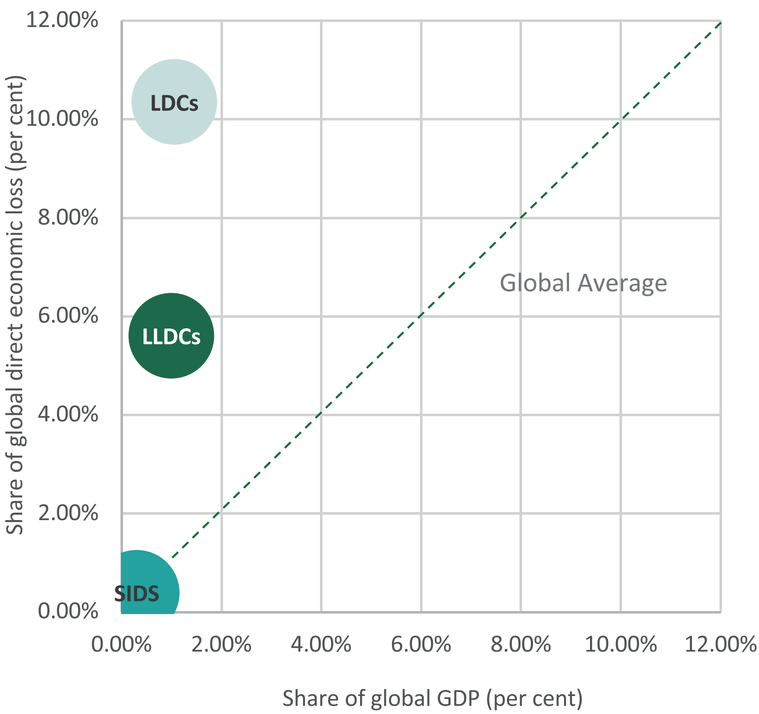
Source: UNDRR analysis and SFM (2024)

Figure 11. Disaster-affected people per 100,000 population, 2014–2023



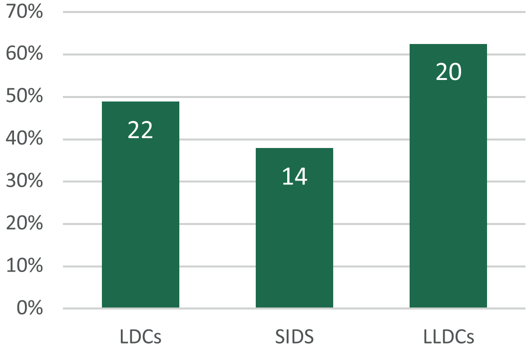
Source: UNDRR analysis and SFM (2024)

Figure 12. Share of global direct economic losses vs share of global GDP, 2015–2023



Source: UNDRR analysis and SFM (2024)

Figure 13. **Proportion and number of LDCs, LLDCs and SIDS reporting the existence of MHEWS**



Source: UNDRR analysis and SFM (2024)

Progress under pressure – what the targets tell us

The seven Sendai targets offer snapshots of both achievement and urgency. Real gains exist, especially in reducing mortality and expanding disaster risk governance. However, economic losses, infrastructure damage, and the number of people affected remain alarmingly high. Gaps in financing, uneven access to early warning, and underreporting of indirect impacts suggest that the full scale of risk is still not fully accounted for.

The data confirm what this report explores in depth: resilience is not yet where it needs to be. It shows a way forward. Countries that invest in risk reduction, strengthen governance, and integrate resilience into development are seeing results. As the deadline for the Sendai Framework approaches, the challenge is to meet the targets and embed resilience as a core driver of sustainable development.

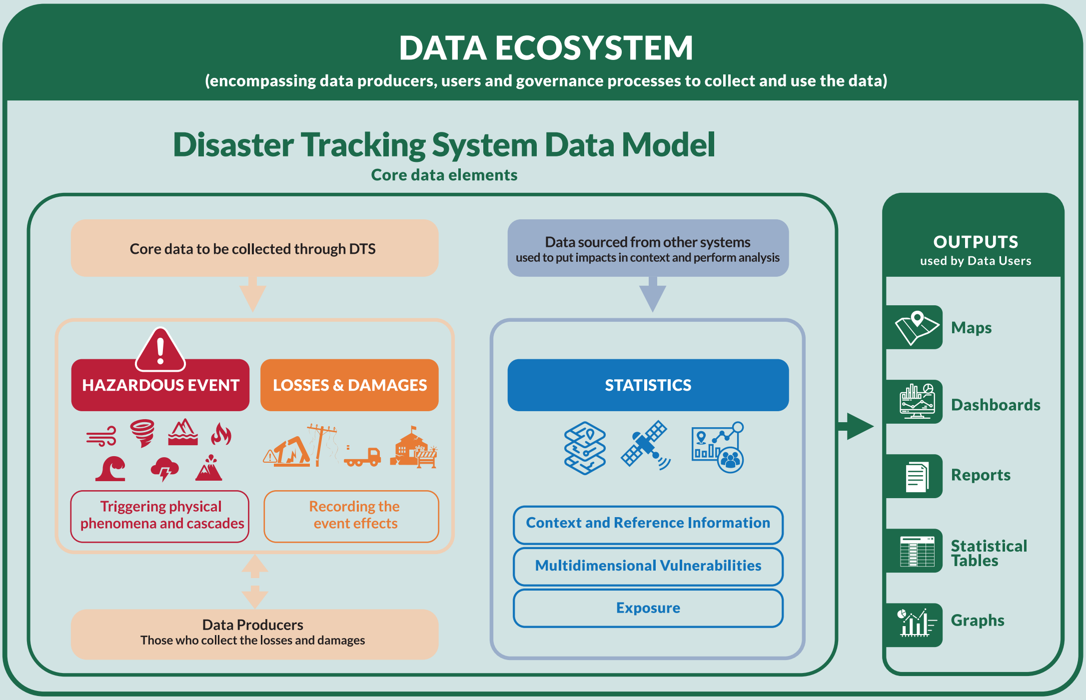
Box 2. **Enhancing the understanding of hazards and disaster impacts**

More than 100 countries have benefited from the well-established DesInventar Sendai disaster loss databases that capture the impact of events on localized scales. Building on this system, the next-generation Disaster Tracking System for hazardous events, losses and damages (DTS) is being developed to enable countries to institutionalize a comprehensive mechanism to monitor the impacts of climate change and disasters and inform decision-making.

Using globally agreed hazard profiles, taxonomies and metrics, the open-source DTS toolkit, developed by UNDRR in collaboration with the United Nations Development Programme and the World Meteorological Organization (WMO) allows decision-makers to track disaster effects across social, productive, and infrastructure sectors with high levels of disaggregation. This provides a granular understanding of damages, disruptions, economic losses, and associated costs, including tail-end impacts from cascading and compounding effects.

Leveraging WMO standards on cataloguing hazards, the DTS connects data on magnitude, footprint, and cascading nature of hazardous events with the resulting impacts, linking physical parameters (e.g. wind speeds, flood heights) to observed effects (e.g. uprooted trees, collapsed bridges).

The DTS further broadens impact monitoring beyond asset damage and economic losses to include non-economic dimensions such as cultural losses, health and wellbeing, food security, biodiversity, and ecosystem health. Its framework supports tracking slow-onset events and processes that often do not have a defined start or end date but result in cumulative losses, eroding resilience and derailing development.



By linking losses and damages records with baseline statistics, vulnerability, and exposure data, DTS contextualizes the meaning of losses and supports analysis of their implications for human development, ecosystem health, and wellbeing. This integration enables a deeper understanding at all scales of how hazards interact with vulnerabilities, exposing how risk inequalities lead to disproportionate impacts across groups, geographies, livelihoods, and sectors.

With enhanced capabilities for data integration, processing, and visualization, the DTS improves both data management and the communication of disaster impacts. It supports evidence-based decision-making across policies, programmes, and actions. Key applications inform DRR financing instruments, recovery planning, and early warning systems, while sector-specific modules enable detailed sector impact tracking to support resilient public and private investment and sector planning decisions.

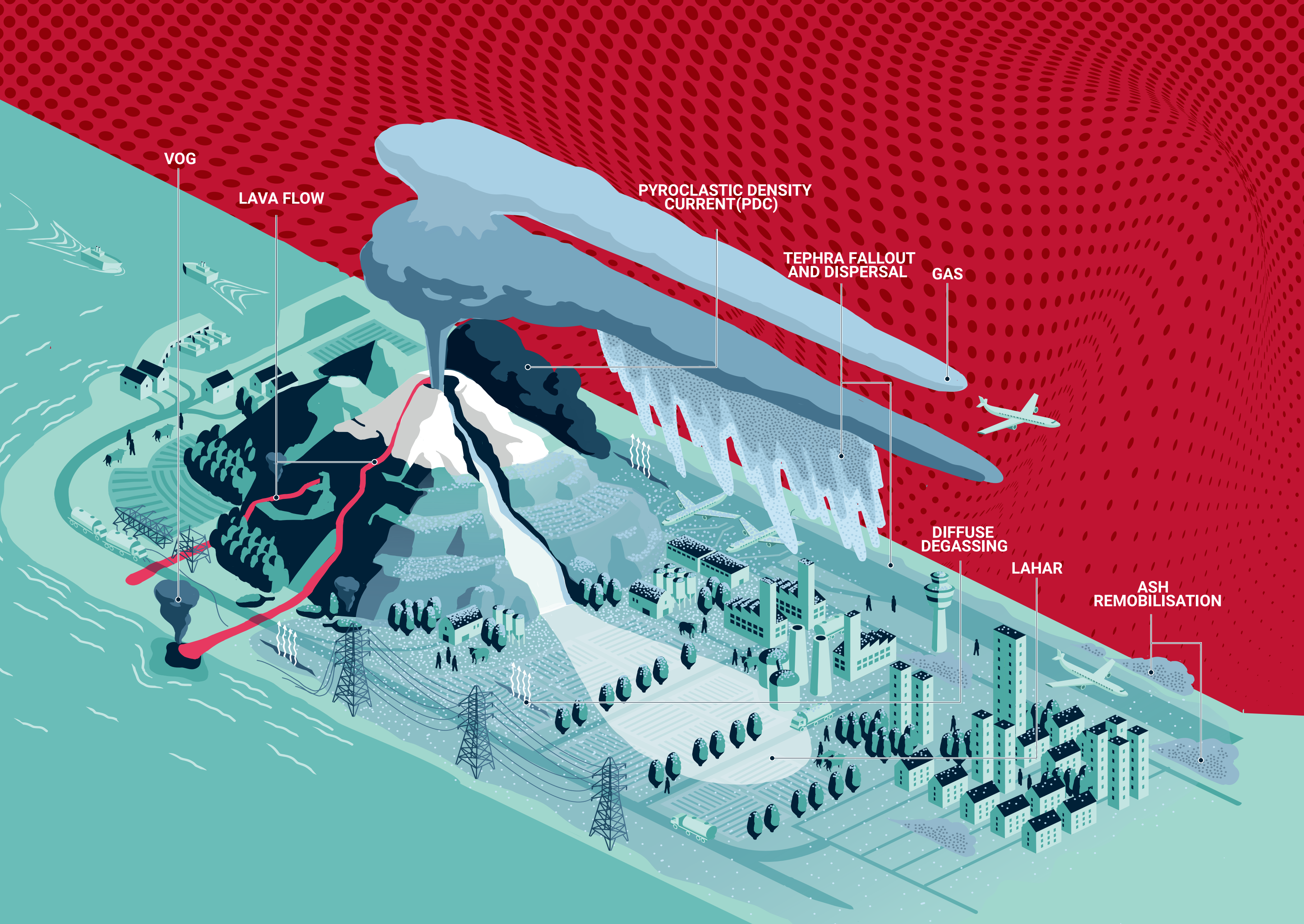
More information: **www.undrr.org/L-DTracking**

Applications and use cases: **www.undrr.org/building-risk-knowledge/disaster-data**

[1]https://sendaimonitor.undrr.org/

[2]https://www.desinventar.net/

[3]In their reporting on Target G, each country assesses its early warning status by providing a score (out of a maximum of 1) for each of the four MHEWS elements, which cover G-2 to G-5. The overall G-1 score is the arithmetic average of the scores from these four indicators.


VOG
LAVA FLOW
PYROCLASTIC DENSITY CURRENT(PDC)
TEPHRA FALLOUT AND DISPERSAL
GAS
DIFFUSE DEGASSING
LAHAR
ASH REMOBILISATION

CHAPTER 2

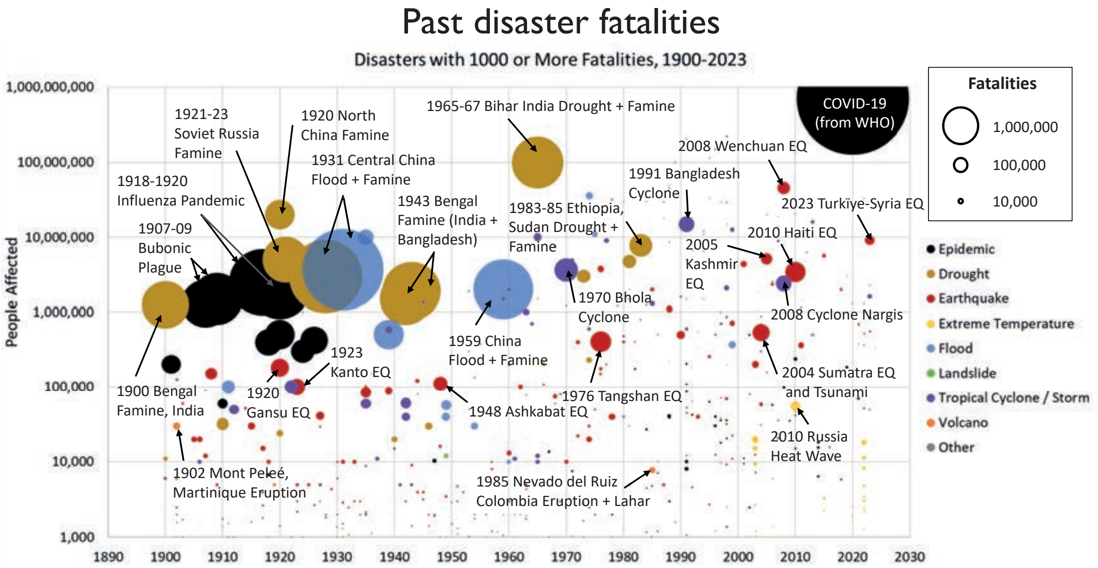
Under-counted risk

Under-estimating the risk of disasters means under-valuing the benefits of risk reduction. As more people and development are concentrated in environmentally vulnerable areas, more assets and livelihoods are exposed to potential hazards. As global populations continue to urbanize, often in high-risk areas such as low-lying coastal areas or seismic zones, there is a greater likelihood of exposure and vulnerability to hazard-related events.

As the previous chapter made clear, disaster risk is increasing globally. However, while risk cannot be eliminated, it can be significantly reduced. Figure 14 below shows the disaster mortality from some of the deadliest disasters between 1900 and today. The data shows how disasters such as floods, storms, earthquakes and tsunamis continue to claim lives regularly worldwide. It also shows how some of the highest fatalities occur in multi-hazard cycles, for example, when a drought and flood occur in close succession and contribute to devastating famines as populations are left vulnerable and exposed.

More positively, Figure 14 also shows that disasters causing over 100,000 deaths have decreased markedly over the past 50 years, partly due to more effective action to reduce disaster risk, strengthened early warning systems and preparedness. Fatalities from hazards such as floods and droughts have decreased in the 21st century, showing positive progress in building resilience in these areas. This decrease in fatalities has been achieved as the global population has increased from 1.6 billion people in 1900 to over 8.2 billion today.[1] [2]

Figure 14. The changing pattern and scale of disasters fatalities since 1900



Data sources: EM-DAT ond WHO, 2024, with estimates of affected people equal to deaths + injuries if not provided in EM-DAT

Figure 14 also points to the changing nature of hazard events. For example, extreme heat disasters have emerged as significant sources of mortality in the 21st century, perhaps a sign of things to come. As climate change impacts become more evident, and current infrastructure is increasingly out of step with its hazard environment, future-oriented planning must adjust and learn from the past while recognising the increasing complexity of a changing hazard risk landscape. For example, a lesson learned in recent Portuguese extreme heat events is that the architecture of some older inland rural homes is no longer well suited to a more extreme climate.[3] This should serve as a wake-up call to the reality of undercounted and changing risk.

Understanding blind spots

There are several reasons for under-reporting disaster risk, including the invisibility of localized hazards in centralized databases, the under-reporting of extensive small-scale disasters, challenges in capturing cascading and transboundary impacts and a tendency to put off planning for potentially catastrophic low-frequency disaster events.

Accounting for extensive risk

Intensive disaster risk describes vulnerability and exposure to rapid-onset hazard events, such as strong earthquakes, active volcanoes, heavy floods, tsunamis or major storms. It also describes a situation with high levels of vulnerability and exposure to these hazards.[4] By contrast, extensive disaster risk arises from situations in which communities are exposed and vulnerable to smaller scale but recurring impacts such as localized floods, landslides or drought. Extensive disaster risk is often exacerbated by poverty, urbanization and environmental degradation.[5]

In such conditions, for instance, in protracted cyclical droughts, the beginning and end dates of a disaster, not to mention the full extent of its impacts, are much harder to define. While these events are seldom publicized, their cumulative effect on livelihoods, health and well-being can be significant.

For instance, as outlined in Figure 15, in Colombia, while intensive disaster events may attract more media attention, small-scale, highly recurrent

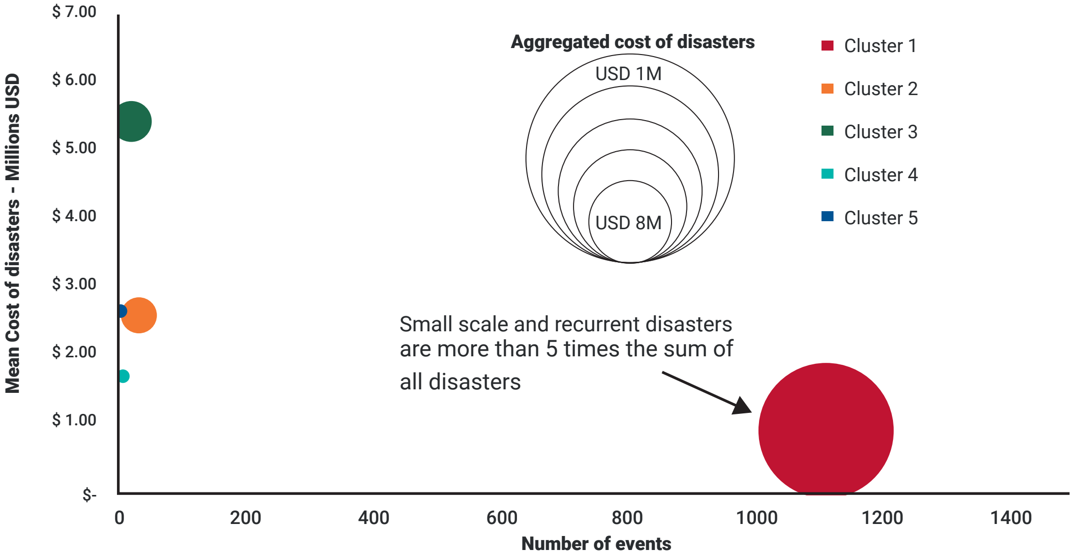
Flooding on the Suba-Cota road. Bogotá, Colombia. 2010.

Credit: Santiago La Rotta

disasters impacting fewer than 330 people each are by far the most frequent, comprising over 1,100 recorded events (compared to less than 30 for any other event cluster).[6] Although these smaller disaster events have a relatively low average cost individually (averaging $924,000), their frequent occurrence makes them the most expensive category of hazard overall, exceeding $1 billion between 2000 and 2023. These disasters – often localized floods, landslides and storms – tend to affect rural communities and urban peripheries, where poverty is high and resilience may be limited.

As outlined in more detail in Chapter 3, improving understanding of extensive disasters and their impacts can be pivotal in helping poor households better cope and recover from disasters.

Figure 15. **Small disasters, significant impacts: The hidden cost of recurrent events in Colombia from 2000 to 2023**



Source: Desinventar

Cluster	Threshold - min affected	Threshold - max affected	Number of events	Mean cost of disasters (USD)	Sum cost of disas-ters (USD)
Cluster 1	0	330	1,113	924,102.35	1,028,525,915.24
Cluster 2	343	1,200	28	2,614,718.91	73,212,129.53
Cluster 3	1,500	3,405	18	5,439,489.90	97,910,818.25
Cluster 4	4,000	5,670	5	1,727,484.95	8,637,424.75
Cluster 5	7,500	10,000	3	2,667,755.00	8,003,264.99

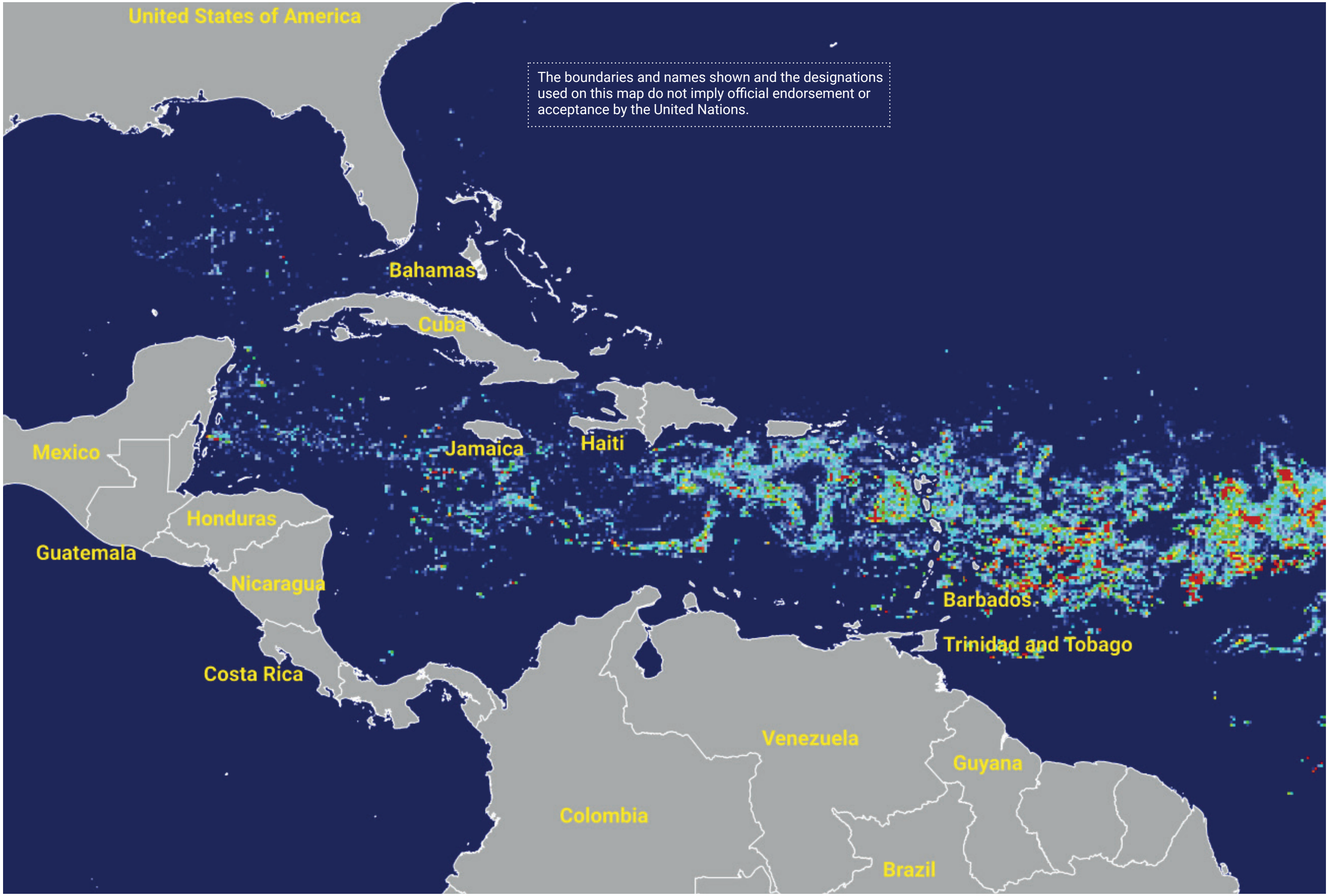
Source: UNDRR using Desinventar, 2025

Including localized and emerging hazards

In addition to not always accounting for small-scale extensive events, many disaster reporting methods count a limited range of hazard types. While it is true that the vast majority of disaster losses occur from one of the predominant "big five" hazard types – namely earthquakes, flooding, storms, droughts and extreme heat – this focus can exclude key localized or emerging hazards. For example, multi-hazard risk models at the core of climate impact forecasts and cost assessments often exclude entire hazard categories such as wildfires, despite their growing significance.

Many model-based damage estimates also overlook the implications of localized hazards, such as algae blooms, which can be highly disruptive in the country or region where they occur but are not prevalent enough to feature at a global scale. To take one example, in the Caribbean, massive influxes of Sargassum seaweed have increased dramatically in recent years, disrupting coastal ecosystems and local economies (Map 1).[7] The dense seaweed mats damage marine habitats, clog fishing gear and hinder coastal activities, leading to substantial financial losses in the tourism and fishing industries.[8] When these floating mats enter coastal waters and wash ashore, they can smother and disrupt important coastal ecological processes and habitats, with cascading effects on the entire ecosystem. The costs of managing and removing seaweed are also considerable, placing additional strain on affected regions. While Sargassum seaweed has been an issue of major concern in the Caribbean since 2011, when widespread blooms in the Atlantic Ocean and massive accumulations occurred, it is still largely unreported at a global level.[9] [10]

Map 1. Sargassum seaweed spread in the Caribbean in 2023



Source: Data: University of Florida. Cartography: UNEP/GRID-Geneva, 2024.

Sargassum Sea Weed % cover on 12.03.2023

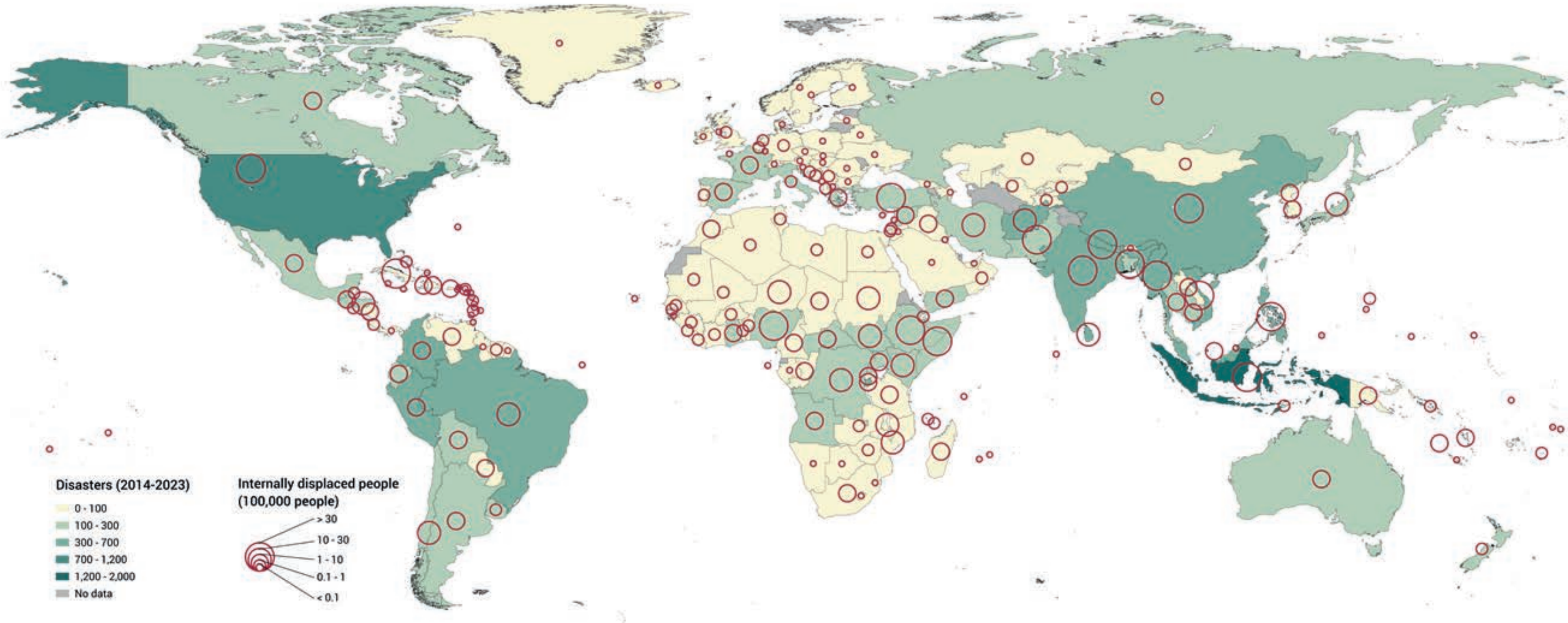
0.0 0.1 0.2 0.3 >0.4

Understand cascading and compounding impacts

Current disaster reporting also tends to underestimate the implications of cascading and compound impacts of disasters on other areas such as mobility or education. A case in point is the COVID-19 pandemic, which led to huge fatalities (see Figure 14, above the first chart), but which also had massive cascading and compounding impacts that undermined entire systems, from children's education to mental health, to micro-chip supply lines. Costs are still being incurred years after the event. Until recently, however, many such cascading impacts were not accounted for when considering disaster impacts.[11]

Another significant but often overlooked cascading impact of disasters is human displacement. Map 2 shows that the number of internally displaced persons (IDPs) from disasters recorded between 2014 and 2023 totalled 237 million.[12]

Map 2. **Number of people displaced by disasters 2014–2023**



Source: Data: IDMC, 2024.
Cartography: GEM Foundation

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.

A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

The map shows that China and the Philippines experienced over 40 million displaced persons each, while India, Bangladesh and Pakistan reported figures between 10 and 30 million. As discussed in Chapters 3 and 4, displacement costs are massive in both social and economic terms.

Disasters can also impact people who have already been forcibly displaced by conflict or other reasons, as the example from Ethiopia below makes clear (Box 3). Indeed, as refugee camps are established as temporary settings, they are often located in areas of higher disaster risk, with limited or low-quality shelter and infrastructure.

Box 3. The displacement–natural hazard nexus: Refugees at risk of flooding in Ethiopia

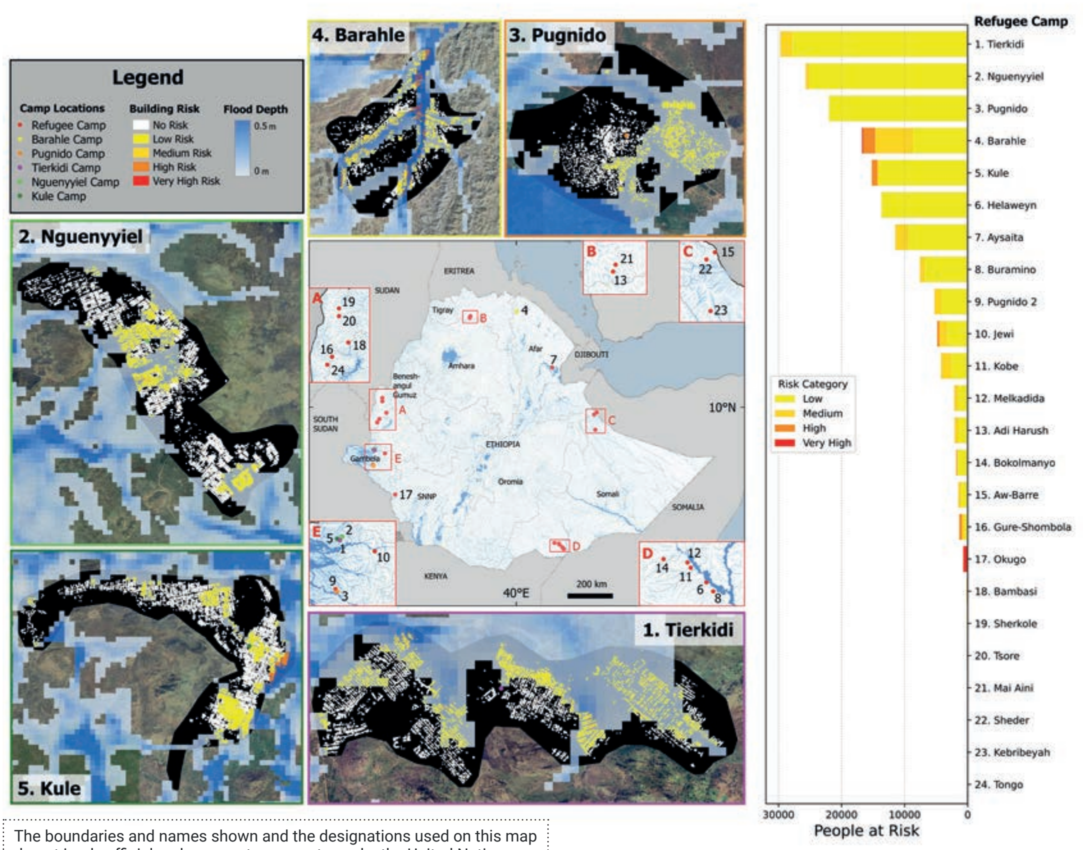
The number of refugees globally has grown over the last decade. Of these, around a quarter live in camps, often located in remote regions and densely populated with temporary shelters. As a result, refugees living in camps are particularly vulnerable to climate impacts such as flooding. To reduce these risks, flood risk assessments can inform the initial siting of refugee settlements, as well as the management of risks once they have been established.[13]

Ethiopia hosts the third largest refugee population in Africa. In 2021, 725,000 refugees – largely from four neighbouring countries – lived across 24 different camps in Ethiopia. Refugee camps in Ethiopia have a history of flooding, yet there is no national picture of which camps are most at risk. A flood risk assessment was done for all 24 refugee camps in Ethiopia to understand which camps were most at risk and address the risk(Map 3).[14]

Combining environmental, spatial and demographic datasets (including global flood patterns, the location of camp boundaries, building footprints and UNHCR-reported camp populations) reveals that over 160,000 refugees have a 1% chance of a flash flood event occurring in any year.[15] In the most exposed camp, Tierkidi, over 29,000 refugees (just under half the camp population) are exposed to this risk. Further classifying flood depths by their relative risk reveals that most of the exposure is due to flooding that is unlikely to be directly life-threatening yet can still pose significant health risks if flood water within the camp is contaminated.

This approach could also be applied usefully to other displacement contexts. Similar analyses, using global flood risk data, could be conducted in other refugee-hosting countries to inform climate adaptation planning and disaster response.

Map 3. **Flood risk affecting 24 refugee camps in Ethiopia**



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations

Source: Bernhofen et al, "Unknown risk: assessing refugee camp flood risk in Ethiopia". Environmental Research Letters. 6 June 2023.

Description:

Centre figure: Location of the 24 refugee camps in Ethiopia and 1 in 100–year flood hazard map; Surrounding maps: The five most exposed camps in Ethiopia and the distribution of risk to structures within the camp; Right chart; People at risk from the 100-year flood in all 24 camps in Ethiopia. The numbering of camps in the chart on the right corresponds to the numbering of camps on the maps.

However, when communities are prepared for and resilient to disasters, they are less likely to have to move when a hazard event occurs or can return home more quickly. As discussed further in Chapter 4, reduced displacement and accelerated recovery times also significantly reduce poverty in poor households.

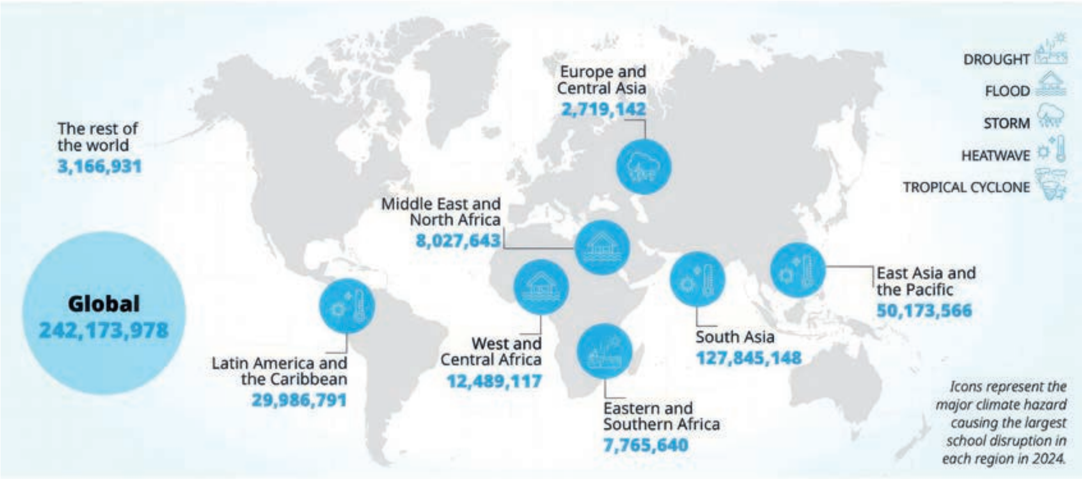
Disasters also impact social progress in areas like education (Box 4). Alongside the direct impacts such as diminished service quality, school closures and damaged or destroyed educational infrastructure, there are cascading effects on education, including lower educational attainment and lower levels of school enrolment due to displacement and psychological stress.

Box 4. The long-term impacts of disasters on education

Across the world, extreme weather events are increasingly disrupting schooling, precipitating learning losses, dropouts and other long-term impacts (Figure 16). Globally, at least 242 million pre-primary and upper-secondary students have experienced school disruptions due to climate events in 2024 across 85 countries or territories. Almost three-quarters (74%) of those affected students are in low- and lower-middle-income countries.[16]

While these impacts are concentrated on the Global South, the effects are nevertheless felt to some extent across the world. Over 99% of children worldwide are exposed to at least one major climate and environmental hazard, shock or stressor, and nearly half of the world's children live in extremely high-risk countries for climate shocks.[17] These erode education outcomes and recent progress in improving school access and learning. The main hazards leading to nationwide school disruptions in 2024 in at least 20 countries were heatwaves, tropical cyclones, storms, and floods – all exacerbated by climate change – while drought led to localized school disruptions (Map 4).

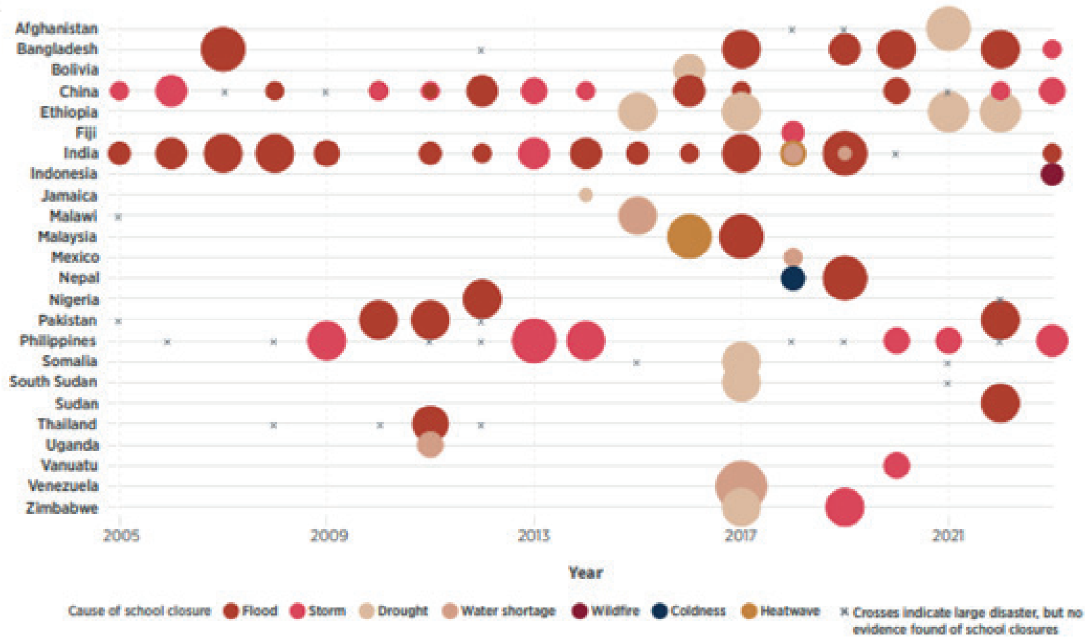
Map 4. Number of students affected by climate-related disaster school disruptions in 2024 (by UNICEF programme region)



Source: UNICEF, 2025. "EARNING INTERRUPTED: Global snapshot of climate-related school disruptions in 2024"

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations

Figure 16. **Most countries experience more climate-related school closures every year**



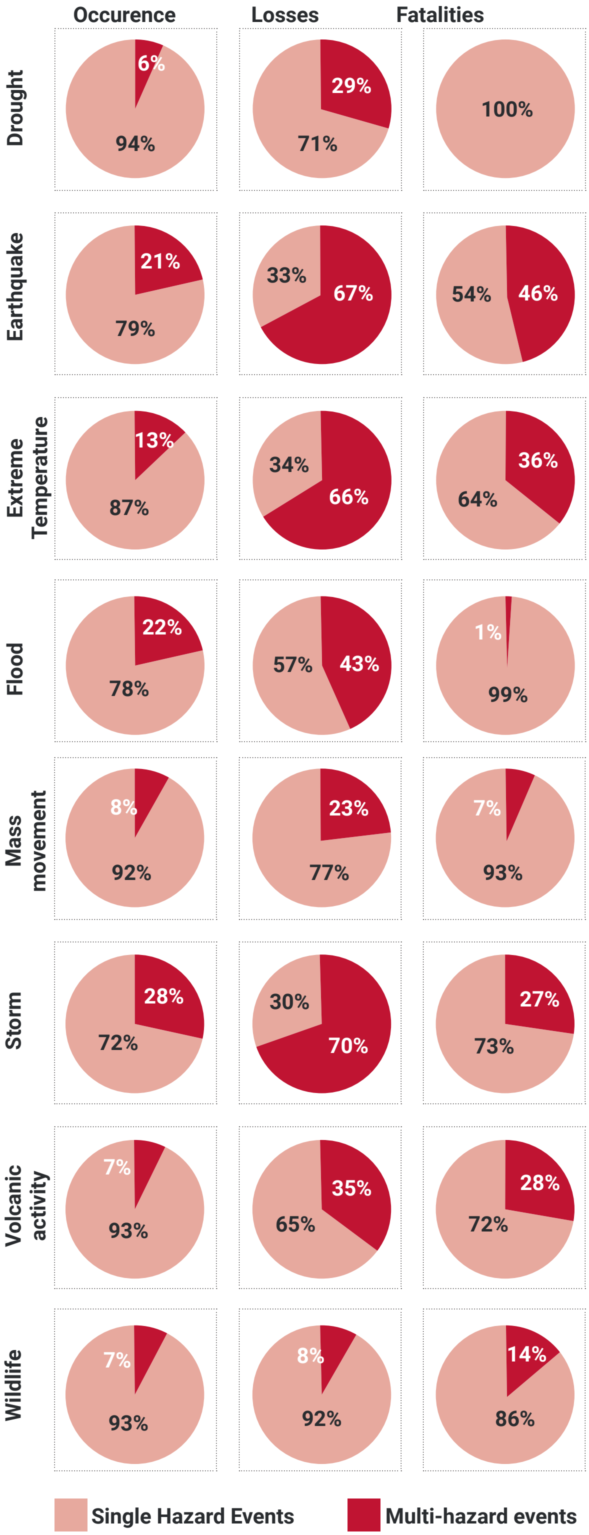
Shown is an index on school closures that combines the duration of school closures and their geographic spread. The larger the bubble the larger either the length of the school closure or the number of people affected, or both. Source: Angrist et. at (2023). Building resilient education systems: Evidence from large-scale randomized trials in five countries. No. w31208. National Bureau of Economic Research. Compiled school closure information based on press releases of the United Nation's Office for the Coordination of Humanitarian Affairs (OCHA) Relief-Web, World Vision, UNICEF, the BBC, and other local outlets.

Source: Venegas Marin, Schwarz and Sabarwal (2024)

Two plus two make five: Counting the impacts of multi-hazard events

Disasters seldom come alone, which is another reason their costs are underestimated. The most damaging events are often multi-hazard: floods trigger landslides, cyclones drive flooding and droughts accelerate desertification. Data suggests that multi-hazard events compound and even increase losses beyond the sum of their parts. To put it another way, in the case of a multi-hazard event, two plus two often equals more than four. For example, analysis of the last century of data recorded in the Emergence Events Database (EM-DAT) maintained by the Centre for Research on the Epidemiology of Disasters at the Université Catholique de Louvain in Belgium shows that while only around 19% of disasters are classified as multi-hazard, these events account for almost 59% of the total economic losses (Figure 17).[18]

Figure 17. Global losses reporting comparing single versus multi-hazard events



Source: Lee et al., 2024.

Multi-hazard events can also result in compounded costs, eroding coping capacity as affected households contend with multiple threats simultaneously. Understanding multi-hazard risk and building this analysis into cost-benefit analysis can improve the effectiveness of preparedness actions and infrastructure investments.

For example, in countries like Chad (Box 5), multiple, successive disaster events add suffering to populations already struggling with conflict, displacement and food security.

Box 5. Floods and displacement in Chad

Chad is the world's most vulnerable country to climate change, and internal displacement is becoming one of its most visible impacts.[19] The country was still recovering from devastating flooding in 2022 when, in the second half of 2024, it was hit by the worst floods in decades.[20] The floods triggered around 1.3 million internal displacements, which is by far the highest disaster displacement figure on record for the country, greater than in the previous 15 years combined. The disaster left nearly 1.2 million people living in displacement as of the end of the year. The floods took place against the backdrop of increasing humanitarian needs associated with the influx of refugees fleeing the conflict in Sudan.[21] It was estimated that about 40,000 Sudanese refugees in eastern Chad were affected by the floods.[22]

Flooding in in of N'Djaména following the rupture of a dyke in Toukra, located along the Logone river, Chad 2020.

Credit: OCHA/Federica Gabellini

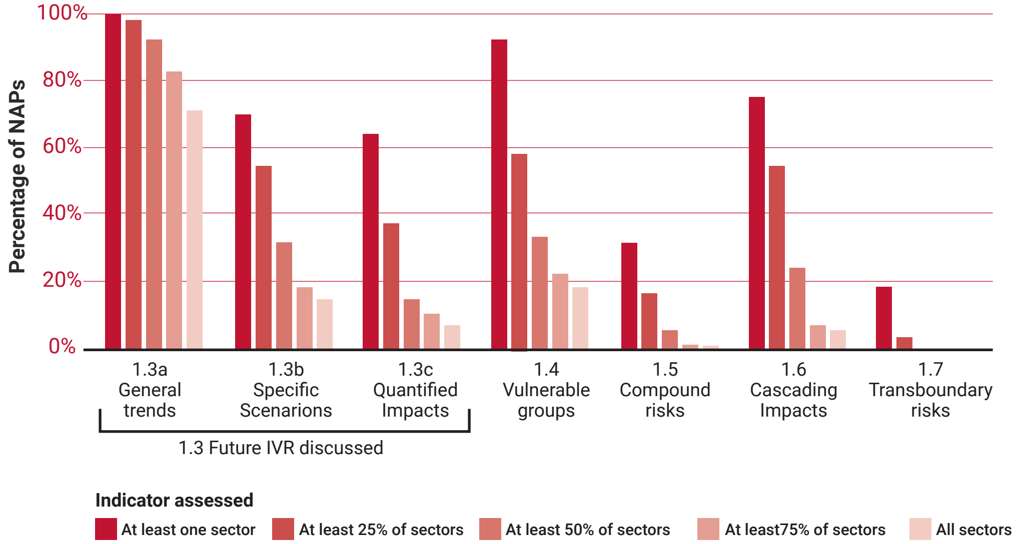
Several factors explain the extent of the devastation the disaster wrought. Above-average rainfall across the country during the rainy season inundated more than 13.9 million hectares of land, including 1.9 million hectares of cropland, undermining the livelihoods of thousands who relied on rainfed agriculture and forcing them to flee.[23] The floods also worsened food insecurity because they occurred at a critical time in the planting season for staple crops including maize, rice, millet and sorghum.[24] Roads were submerged, damaged or destroyed, hampering the delivery of much-needed humanitarian aid to vulnerable groups, including internally displaced women and children, who were among the worst affected. Large areas of the country were underwater for days and in some cases weeks, contaminating water sources and heightening the risk of waterborne diseases.[25]

Internal displacement occurred across nearly all 23 of the country's provinces, but Mandoul, Mayo Kebbi Est, Borkou and Lac accounted for more than half of all the movements reported. Nearly 218,000 homes had been destroyed across the country as of 1 October, prolonging the plight of many of those displaced.[26] Urban areas were not spared.[27] In the capital, N'Djamena, the Logone river was at its highest level in more than 30 years, reaching more than eight metres in early October.[28] Thanks to previous investments in water management, 57,000 displacements were recorded there, fewer than a quarter of those recorded in 2022.[29]

Comprehensive data on the scope and scale of displacement will be critical to inform future policymaking, but there remains a significant gap. Indeed, estimates are obtained using housing destruction as a proxy, hampering a full understanding of the impacts and duration of displacement and how different initiatives to support IDPs succeed in helping them achieve a durable solution.

Under-counting cascading risk is also evident in climate change adaptation planning. For example, Figure 20 shows the prevalence of risk analysis that considers compound, cascading or transboundary risks in National Adaptation Plans.[30] (Figure 18). While the chart shows encouraging progress in considering impact, vulnerability and risk, sectors are less systematic in analyzing more complex risks despite the increasing availability of tools that can help this process, several of which are discussed in more detail later in this report.

Figure 18. Prevalence of indicators assessing robustness of impacts, vulnerability and risks (IVR) information on impacts, vulnerability and risks across sectors within individual National Adaptation Plans



Source: UNEP, 2024

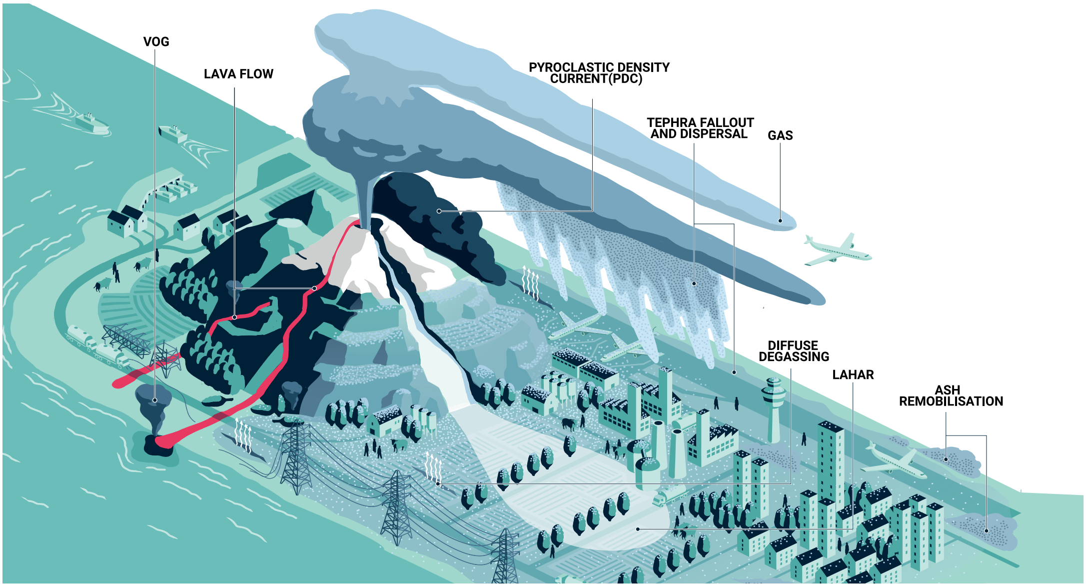
Expecting the unexpected: Factoring in catastrophic risk

The greatest under-estimation of the potential future disaster costs is the blind spot in accounting for possible 1-in-100 or even 1-in-1,000-year events – those that, while having a low probability of occurring can cause catastrophic impacts when they do. Human history contains multiple examples of such disasters, like the 1815 Mount Tambora volcanic eruption described below (Box 6). More recently, disasters like the 2004 Indian Ocean earthquake and tsunami, or the COVID-19 pandemic, have had catastrophic impacts. Similarly, the 2010 magnitude 4 eruption of Eyjatiallajökull, Iceland, resulted in an ash cloud closing European airspace, disrupting global transport networks and supply chains with an estimated cost to the global economy of $5 billion.[31] However, as most contingency planning exercises focus on the most frequent and likely scenarios, catastrophic events are often deprioritized in disaster planning and investment.

An event such as a major volcanic eruption could have massive impacts. As outlined in the figure below, models suggest that for a high-impact eruption scenario, economic losses over a 5-year period could cost $1.2–4.8 trillion, the equivalent of 0.2% to 0.7% of global GDP.[32] Even moderate eruptions can cause global impacts, including stratospheric warming, surface cooling and an increased likelihood of extreme weather events such as droughts, storms and frosts.[33] These climatic effects can last from a few months to several years, or if multiple large eruptions occur, up to two decades.[34] Furthermore, global population and GDP exposure to volcanic hazards is expected to more than double by 2100, due to demographic and other trends, with Southeast Asia, Eastern Asia and Central America being most affected. (Figure 19).[35]

Figure 19. Volcanic risk and its potential impacts

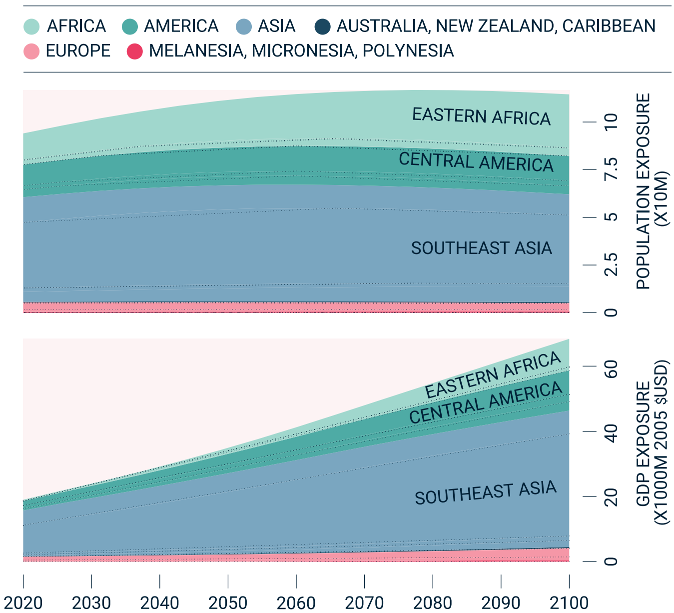
a) Illustration



b) Projected regional volcanic exposure

Projected regional volcanic exposure

Projections of population and GDP located within 100 km of a volcano active during the last 10,000 years. Projections to 2100, following the IPCC's second shared socioeconomic pathway (SSP2: Middle of the road).



Source: University of Geneva – Department of Earth Sciences (2024)

Although infrequent, an event like a major volcanic eruption would have a massive development impact, and recoveries and contingencies must be planned. Initial infrastructure impacts could include damage or disruption of transportation hubs, communication networks, electricity grids, water supplies and trading routes.[36] Figure 20 identifies some of the systemic cascading impacts of a major volcanic eruption. These include significant disruptions and failures across key interconnected systems such as agriculture, health and trade that would likely escalate on a global scale, resulting in severe economic impacts, population displacement and global food insecurity.[37]

Figure 20. Systemic and cascading impacts from volcanic eruptions

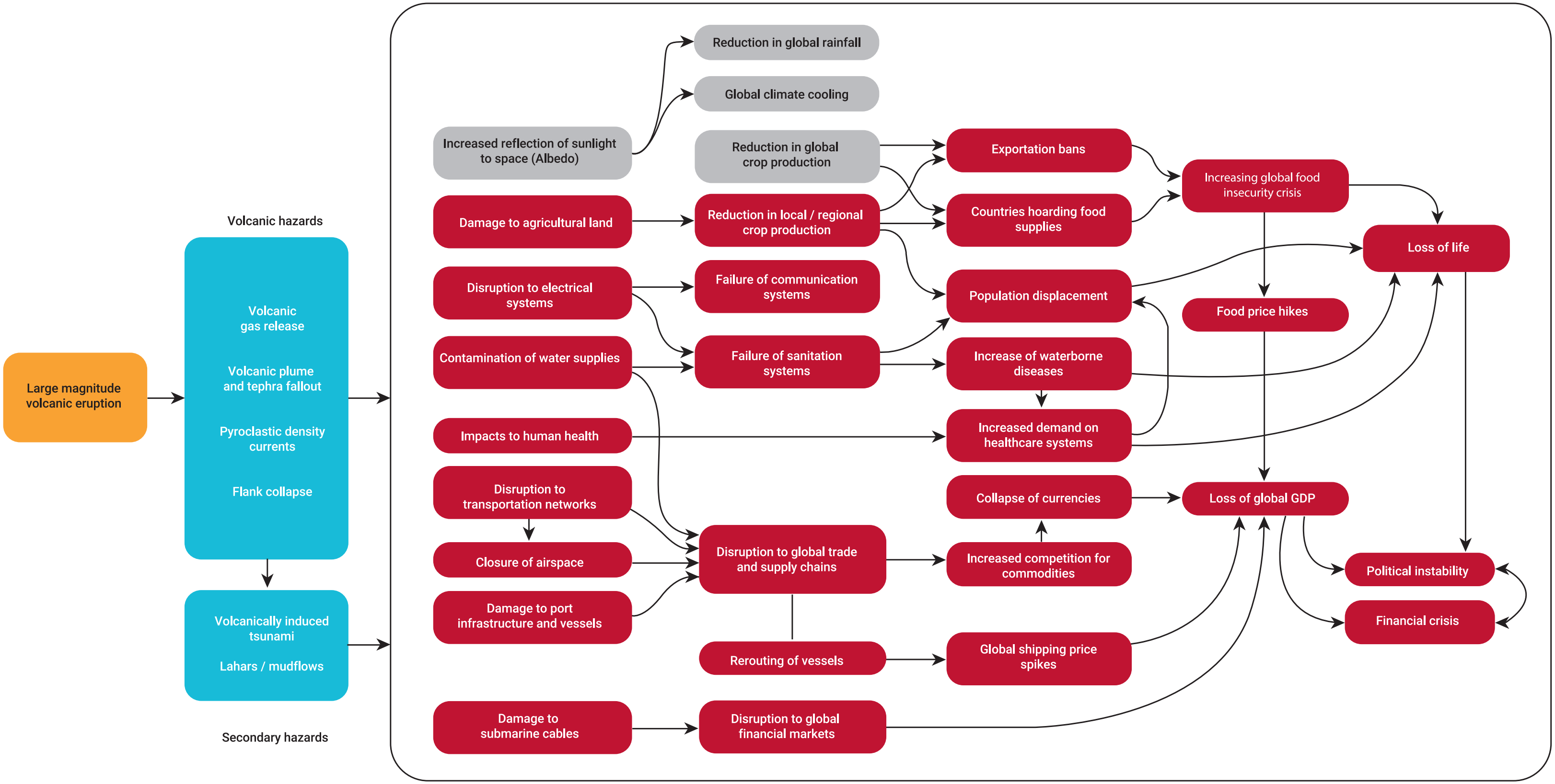


Figure 1. Map of the systemic and cascading impacts that could result from a large magnitude eruption, where green boxes are longer-term impacts from a one-year onwards and purple boxes are immediate impacts. The map was produced from exert elicitation workshops using a scenario of a Tambora-like eruption in Indonesia.

Source: Mani, 2025.

Box 6. Lessons from the 1815 Mount Tambora volcanic eruption

One of the most extreme volcanic shocks was triggered by the 1815 magnitude 7 eruption of Mount Tambora in Indonesia. This event released 60 megatons of sulphur dioxide, resulting in short-term climate anomalies, primarily in the northern hemisphere. Though separated by more than two centuries, this catastrophe offers countries today important lessons for planning and preparedness, particularly on how the fallout from a local disaster can create unanticipated and protracted impacts worldwide.

During the summer of 1816, a year after the eruption and thousands of miles away, Europe experienced temperatures 1–2^{0}C below average due to the eruption; summer frosts destroyed harvests in the United States of America, and anomalous weather was experienced throughout Asia. European summer temperatures remained abnormally cool in 1817 and 1818, leading to the worst food crisis of the 19th century.[38 39]

A comparable disaster today could prove similarly devastating. The climatic impacts from large magnitude eruptions would adversely affect global food production, with crop failure leading to price hikes and challenges to food security. Although more research is needed to understand the relationship between volcanic-climate interactions and impacts on global food production, initial estimates suggest that a large magnitude eruption of this scale could result in a loss of annual food consumption for 1–2.9 billion people.[40] Eruptions of a similar scale to the 1815 Tambora eruption are considered as frequent as 1-in-4 to 1-in-6 per century.[41]

Credit: Vesuvius in eruption: William Turner between 1818 - 1820

Unfortunately, human actions and demographic trends make large, potentially catastrophic disasters more likely.[42] For instance, because of climate change, sea levels are already rising at a rate of 3.3 millimetres per year, due to thermal expansion of the ocean water and melting land glaciers.[43]

IPCC data also increasingly points to the potential for rapid changes in hazard occurrences, such as the melting of polar icesheets, governments and financial markets often overlook the potential economic risks posed by these events.

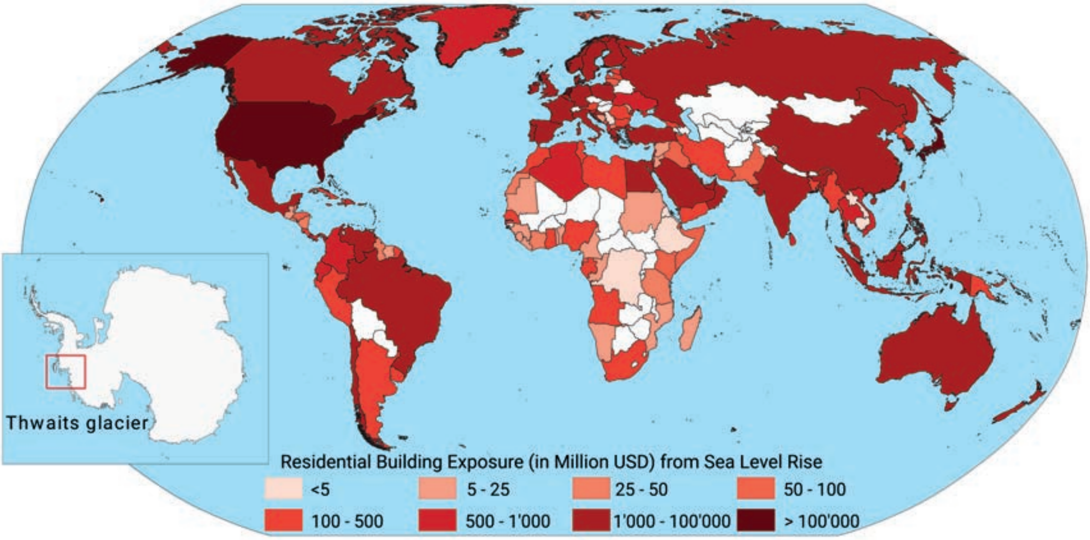
For example, one area of concern is the rapid melting of the Thwaites Glacier. This glacier measures around 190,000 square kilometres, similar in size to Kyrgyzstan or Senegal. If it slides into the ocean, it will generate a rapid and irreversible elevation of global sea levels of more than half a metre.[44]

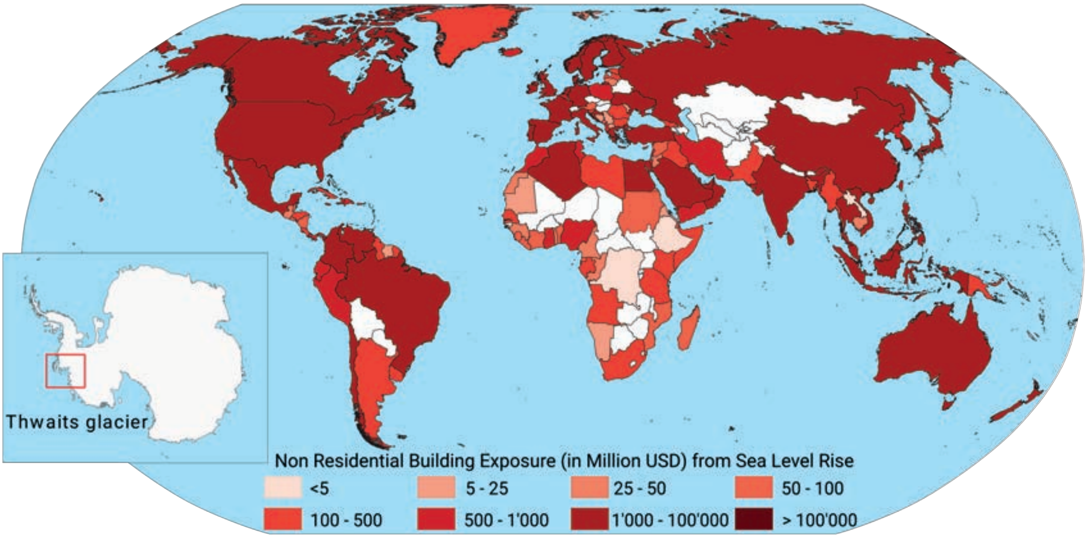
The economic value of infrastructure exposed as a result would amount conservatively to more than $1.8 trillion, affecting a range of areas from low-lying Pacific states like Kiribati and the Marshall Islands to coastal megacities such as New York and Jakarta (Map 5).

Unfortunately, the Thwaits glacier is not the only underestimated potential catastrophic risk associated with current human action. Chapter 3 of this report highlights several other areas where increasing risk and climate volatility could trigger large-scale disasters and where stepped-up risk reduction investment can prevent potentially massive negative impacts.

Overall, it is essential, pragmatic and cost-effective to start preparing better for potentially catastrophic disasters now. Box 7 below describes a positive case of how this is beginning to happen using probabilistic risk analysis that simulates the potential impact of a 1:1000-year event. This approach enables the city of Paris, France, to better understand the possible effects of a low-frequency, high-impact flood event to prepare sectors like tourism and prevent damage to national cultural assets like the Louvre Museum.

Map 5. Modeled economic losses to residential and non-residential buildings associated with a potential collapse of the Thwaits Glacier





Source: Data: MERIT Hydro, 2019.
Cartography: UNEP/GRID-Geneva, 2024.

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.

A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

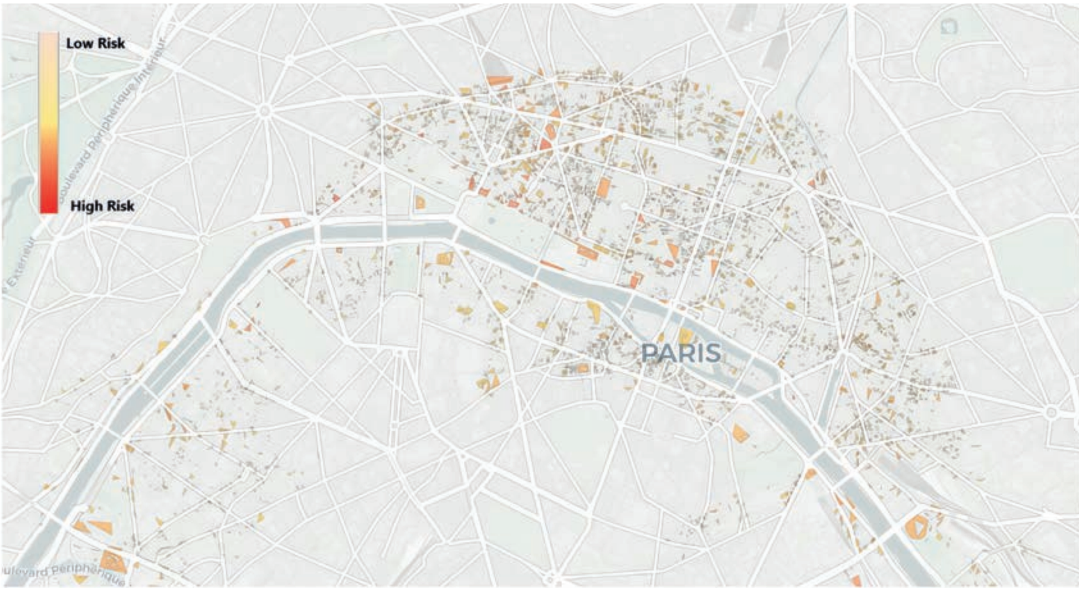
Box 7. Beyond economic costs: The exposure of the tourism sector and cultural institutions to an extreme flood scenario in Paris, France

Rising physical risks and transition policies aimed at mitigating environmental crises have direct consequences for the macroeconomy and the financial system. In the October 2018 progress report, the Network for Greening the Financial System acknowledged that "climate-related risks are a source of financial risk. It is therefore within the mandates of central banks and supervisors to ensure the financial system is resilient to these risks."[45] One of the channels through which physical climate hazards can threaten the financial system is through credit risk when firms' assets are affected. Indeed, damages to transferable assets can impair their productive and thus repayment capacities, while losses on the property value they own can result in a loss for the banks.

While physical risk events could have a macroeconomic impact, it is necessary to understand the mechanism through which they affect firms' assets, taking into account sector specificities. This is the goal of the Digital Twins project, developed by Banque de France, De Nederlandsche Bank and Hong Kong Monetary Authority, that virtually reproduces parts of the economic and financial systems to simulate shocks to them.[46] Using granular geolocated data, the Banque de France modelled a representation of Paris buildings and firms' operating establishments, enabling them to follow, in real-time, flood hazards and their propagation to the financial system, but also to assess the impact of different scenarios with varying intensities.

The tool is based on a destructive 1-in-1000-year scenario to assess the potential exposure of the tourism sector (including accommodation, food services and cultural institutions) to catastrophic flooding. Regarding the tourism sector, the study found that 5,127 business establishments belonging to 4,728 firms would be exposed, with estimated losses reaching around €2 billion in the extreme scenario. For 56% of these firms, this loss would represent more than 10% of their total assets. Given that around 15% are already highly indebted, the businesses could represent a risk for the banks that had lent them money. As for the exposure of cultural assets, in this scenario, 60 museums and some 151,045 artworks were also exposed.[47]

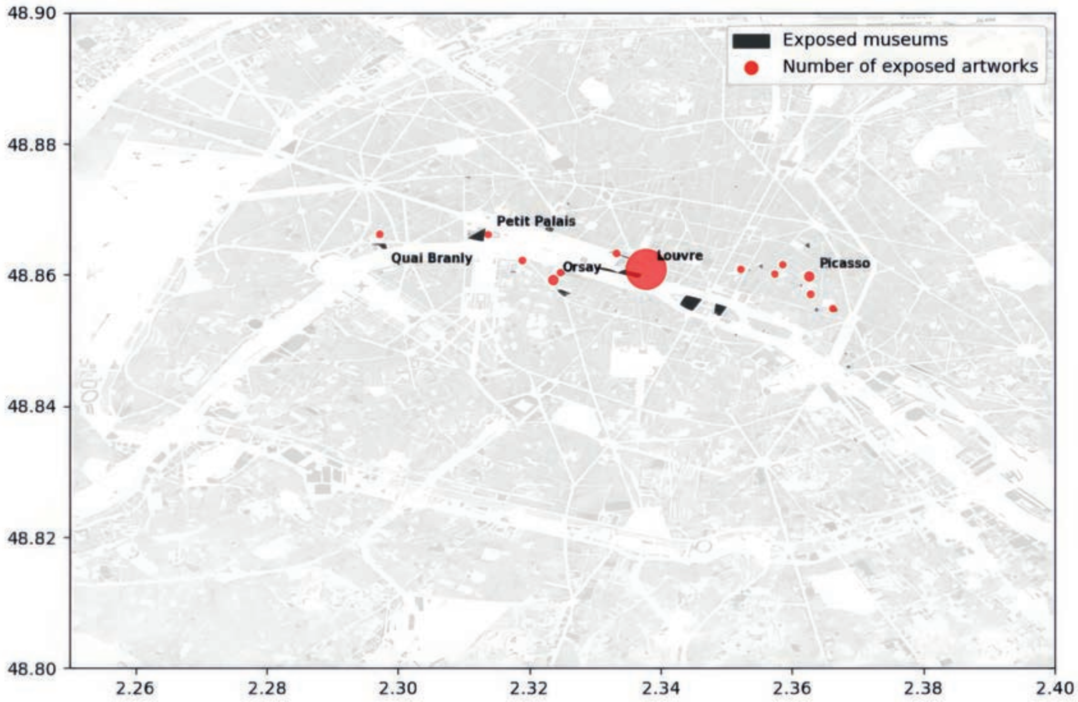
Map 6. Modeled potential losses of cultural assets from extreme floods in Paris, France



Source: de L'Estoile and Kerdelhué, 2025. "Exposure of the tourism sector and cultural institutions to an extreme flood scenario in Paris". Banque de France.

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Map 7. **Modeled potential exposure of museums and artwork in Paris, France to extreme floods**



Source: de L'Estoile and Kerdelhué, 2025. "Exposure of the tourism sector and cultural institutions to an extreme flood scenario in Paris". Banque de France.

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Ways forward

Undercounting the risk of disasters can lead to undercounting the risk reduction benefits. This chapter has pinpointed several ways disaster risk is often undercounted and therefore under-addressed. It has underscored the urgency of waking up to the changing nature of hazards and stepping up action to prevent disasters from destroying lives and livelihoods. For sustainable development to continue, it is essential that countries:

- **Ensure small-scale, extensive disasters are accounted for.** Extensive disasters are often preventable, and averting disaster impacts in areas like displacement and education can have a significant effect in helping communities to emerge from poverty and develop sustainably.

- **Consider localized and emerging hazards in planning and investment decision-making** Governments must understand their local risk landscapes, looking across a full range of hazards to understand the risks in their context. Resources such as the UNDRR ISC Hazard Profiles can help structure such enquiries, and drawing on local knowledge is also key.[48]

- **Understand cascading and compounding impacts and consider multi-hazard impacts.** Understanding risk in a complex global world means investing in analytics that can understand individual hazards and multi-hazard events and their cascading impacts.

- **Anticipate the impacts of rare but catastrophic hazard events.** Creating a less volatile, more resilient future requires taking steps to manage lower probability, but high-impact, potentially catastrophic events. Given the potential devastation these events can bring, governments and the international community need key plans and investment mechanisms to reduce their impact and accelerate recovery in the case of need.

While currently disaster losses are mounting, they are not inevitable. Investing in resilience is essential, profitable and urgent. World Bank analysis that tested thousands of socioeconomic and climate scenarios and found that investments in resilient infrastructure were beneficial 96% of the time.[49] Moreover, a resilient-building action, like investing in early-warning community capacity building, can often reduce risks across a wide range of hazards.

Investing in risk knowledge to address current disaster risk understanding blind spots can help put in place more accurate and effective cost-benefit analysis and investment strategies. An improved understanding of disaster risk also helps identify positive opportunities and co-benefits, such as forest fire prevention, improved air quality and lower carbon emissions, as discussed in Chapter 3.

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[1] United Nations 2001

[2] United Nations 2002

[3] UNDRR, 2024.

[6] By applying K-means clustering to the number of affected people reported in DesInventar, UNDRR identified five statistical clusters of disaster impact. These clusters reveal patterns of disaster occurrence and economic burden, but it is essential to clarify that the thresholds used are arbitrary and for illustration purposes only: they do not represent an official classification of intensive or extensive risk by the Colombian government. Instead, they emerge organically from the data, providing a statistical basis to analyze disaster impact distribution. K-means clustering is a data-driven method that helps group similar events together based on specific characteristics, revealing natural patterns (in this case, the number of people affected by each disaster) without predefining categories.

[7] Vázquez-Delfín et al, 2021

[8] UNEP, 2021

[9] Note: this map shows Sargassum natans and Sargassum fluitans, two species of this algae, which are found in the Sargasso Sea and the Great Atlantic Sargassum Belt (GASB)

[10] WECAFC, 2023

[11] UNDRR and UNU-EHS, 2022.

[12] IDMC, 2024

[13] Hawker et al, 2025

[14] Bernhofen, Blenkin, and Trigg, 2023

[15] Also described as a “1-in-100-year flood”, this term is often misunderstood as signifying that a disaster on this scale can only happen once in a century. In practice, despite the low probability in a given year, these events may in practice occur multiple times.

[16] UNICEF, 2024

[17] UNICEF, 2024

[18] Lee et al, 2024

[19] Notre Dame Global Adaptation Initiative, University of Notre Dame, 2024

[20] IFRC, 2024

[21] UNFPA, 2025

[22] UNHCR, 2024

[23] FAO, 2024

[24] ACAPS, 2024

[25] UN WFP, 2024 ; Buechner, 2024 ; IFRC, 2024 ; UNICEF, 2024a

[26] ACAPS, 2024

[27] IFRC, 2024

[28] Reuters, 2024

[29] World Bank, 2024 ; OCHA, 2022a ; IFRC, 2022 ; OCHA, 2022b ; IOM, DTM Chad, 2024

[30] UNEP et al, 2024

[31] Kelman et al, 2023

[32] LLoyd’s and Cambridge Centre for Risk Studies, 2024

[33] Newhall, Self, and Robock, 2018

[34] Newhall, Self, and Robock, 2018

[35] University of Geneva - Department of Earth Sciences, 2025

[36] Wilson et al, 2014

[37] Mani, Tzachor, and Cole, 2021

[38] N. Wilson et al, 2023

[39] Cole-Dai et al, 2

[40] Puma, Chon, and Wada, 2015

[41] Cassidy and Mani, 2022

[42] Calvin et al, 2023

[43] Magnan et al, 2022

[44] Davis et al, 2023

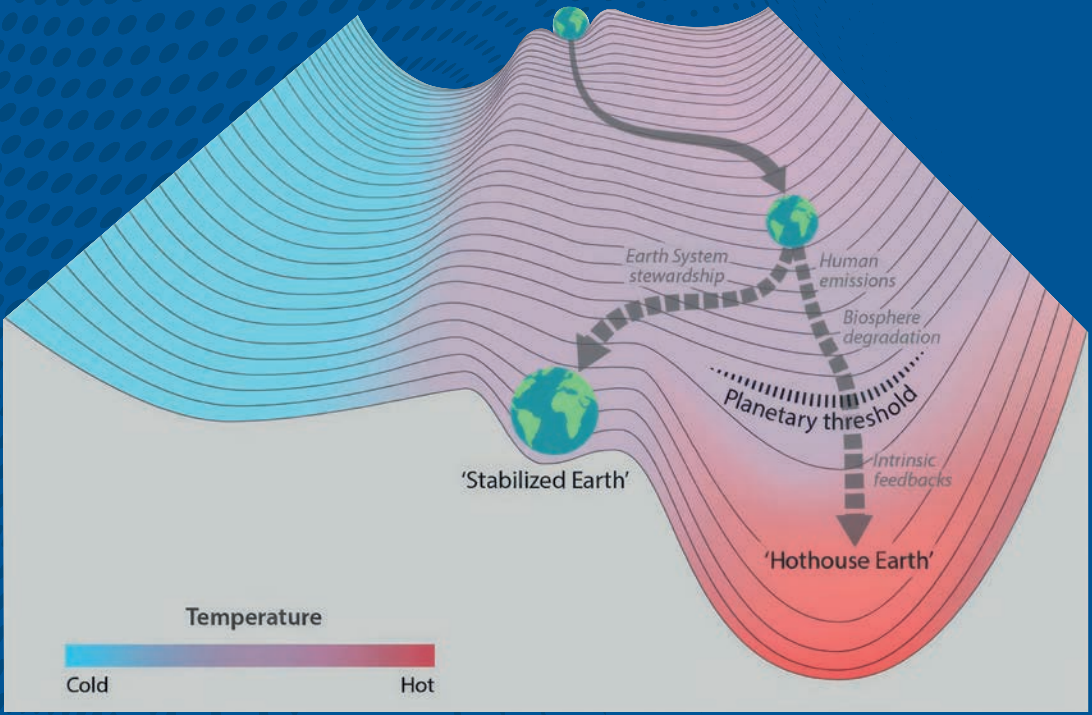
[45] Network for Greening the Financial System, 2018

[46] Cole-Dai et al, 2

[47] Case study developed for GAR 2025, Etienne de L’Estoile, Lisa Kerdelhué, Banque de France, Financial Stability Directorate

[48] United Nations Office for Disaster Risk Reduction, 2024

[49] Hallegatte, Rentschler, and Rozenberg, 2019



Earth System stewardship
Human emissions
Biosphere degradation
Planetary threshold
Intrinsic feedbacks
'Stabilized Earth'
'Hothouse Earth'
Temperature
Cold
Hot

CHAPTER 3

The path to resilience in a volatile world

Increasing risk, when combined with inadequate resilient investment, poses a major threat to sustainable development. Earthquakes, for example, can wipe out years of progress in mere seconds, while slow-onset hazards such as drought hold back progress every day across a range of SDG areas. Yet instead of taking appropriate action to urgently address these issues, humans are making choices that jeopardize nature's equilibrium and exacerbate disaster risk.

Many of these losses can be prevented, and it is cost effective to do so. This chapter focuses on the benefits of risk reduction to people and the planet, and on how action to prevent hazards from becoming disasters can have immediate and long-term impacts on wellbeing. It can also stop disasters from compounding and creating widespread indirect impacts. As discussed below, a wealth of tools is available to reduce vulnerability and ensure people and assets are not in harm's way.[1]

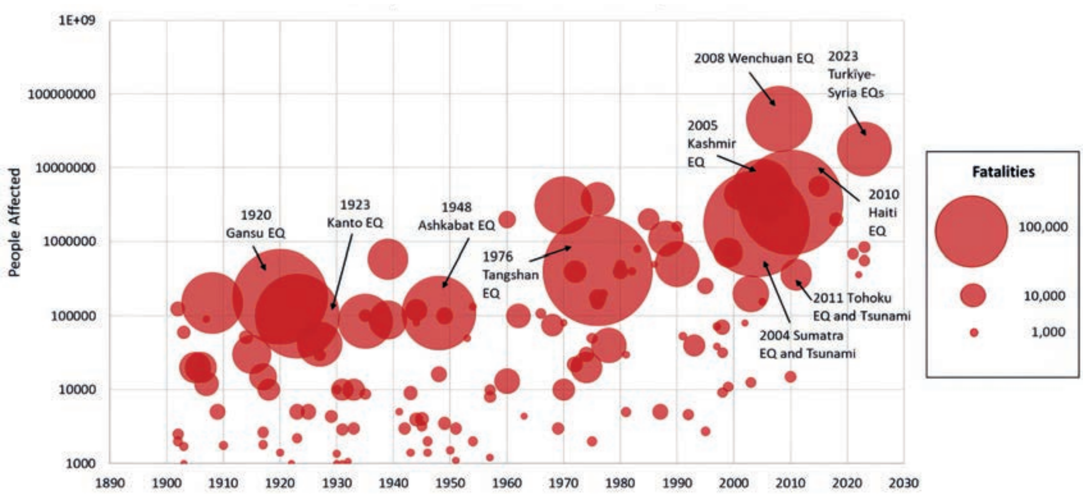
Shaking foundations: Human losses and key hazards

Between 2000 and 2023, five hazards triggered 90% of disaster deaths: earthquakes (50%), extreme heat (18%), storms (14%), floods (8%), and droughts (2%)[2]. This chapter starts by outlining how reducing the risk of these disasters can be a powerful lever to accelerate sustainable development. It highlights examples where multi-hazard integrated risk reduction investments can have cascading benefits on SDG achievements globally, from enhancing food security to improving air quality, and reducing greenhouse gas emissions. These investments benefit everyone, but their impact is most pronounced where the need is highest.

Reducing earthquake risk

Figure 21 shows that earthquakes continue to cause high death tolls despite major advances in understanding earthquake risk and in deploying improved engineering techniques to reduce loss of life. Since 1900, 12 earthquakes have had single-event fatalities totalling 50,000 or more, with five occurring in 2000 or later. The most recent was the 2023 Kahramanmaraş earthquake sequence, which killed over 50,000 people in Türkiye and another 8,700 in northwest Syria as vulnerable multi-story buildings collapsed by the thousands.

Figure 21. **Earthquakes with 1,000 or more fatalities globally, 1900-2023**

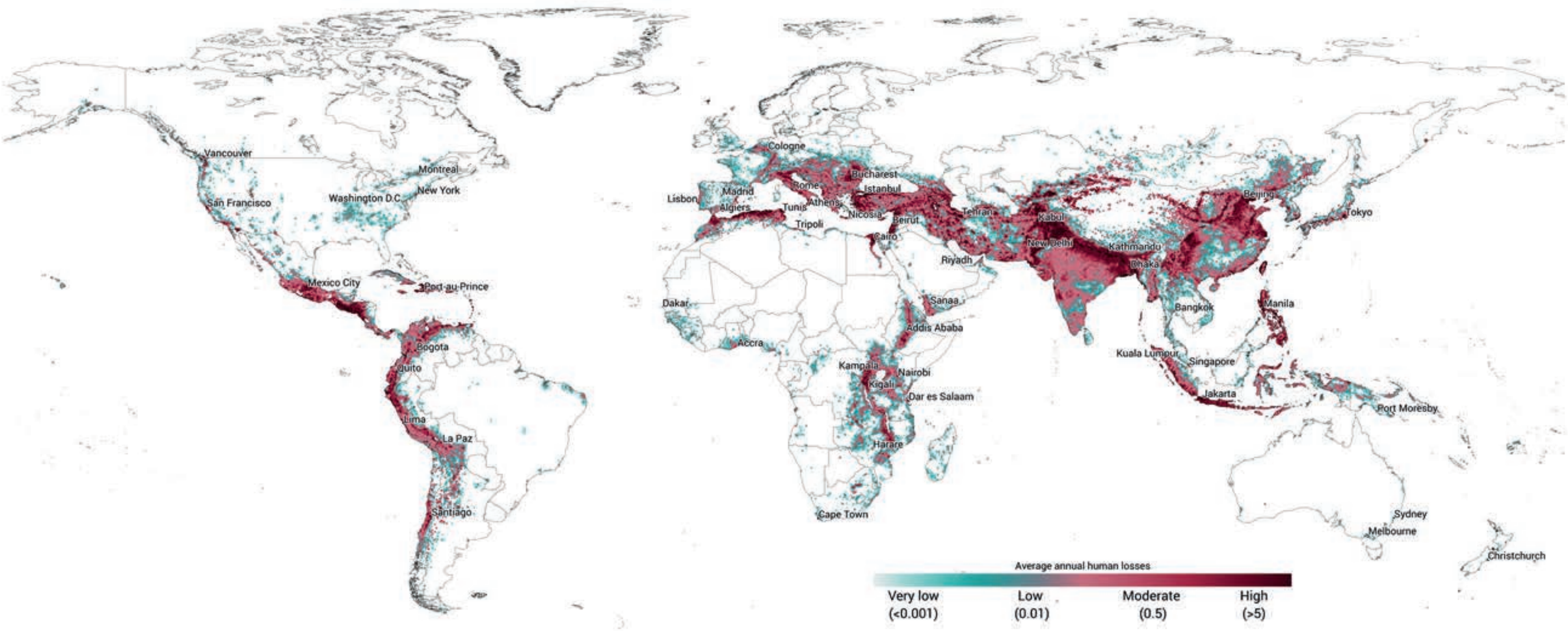


Source: GEO-HAZARDS international using the International Disaster Database (EM-DAT)(CRED, 2024), with affected people estimated as deaths plus injuries if not provided in EM-DAT

Seismic risk is concentrated in certain countries and regions. Map 8 shows the global average annual human losses from earthquakes, based on current seismic risk and demographics. For instance, based on analytical modelling of average annual loss (AAL), China, Pakistan and Turkey should each expect over 2,000 fatalities every year due to earthquakes.

However, while this map clearly reflects where earthquake risk is highest, understanding the hazard is only part of the story. As the extreme risk locations show, the underlying causes of high-fatality earthquakes have resulted in a higher level of risk in some areas, particularly in low- and middle-income countries.

Map 8. **Average annual losses in terms of fatalities due to earthquakes worldwide**



Source: Silva et Al, 2019

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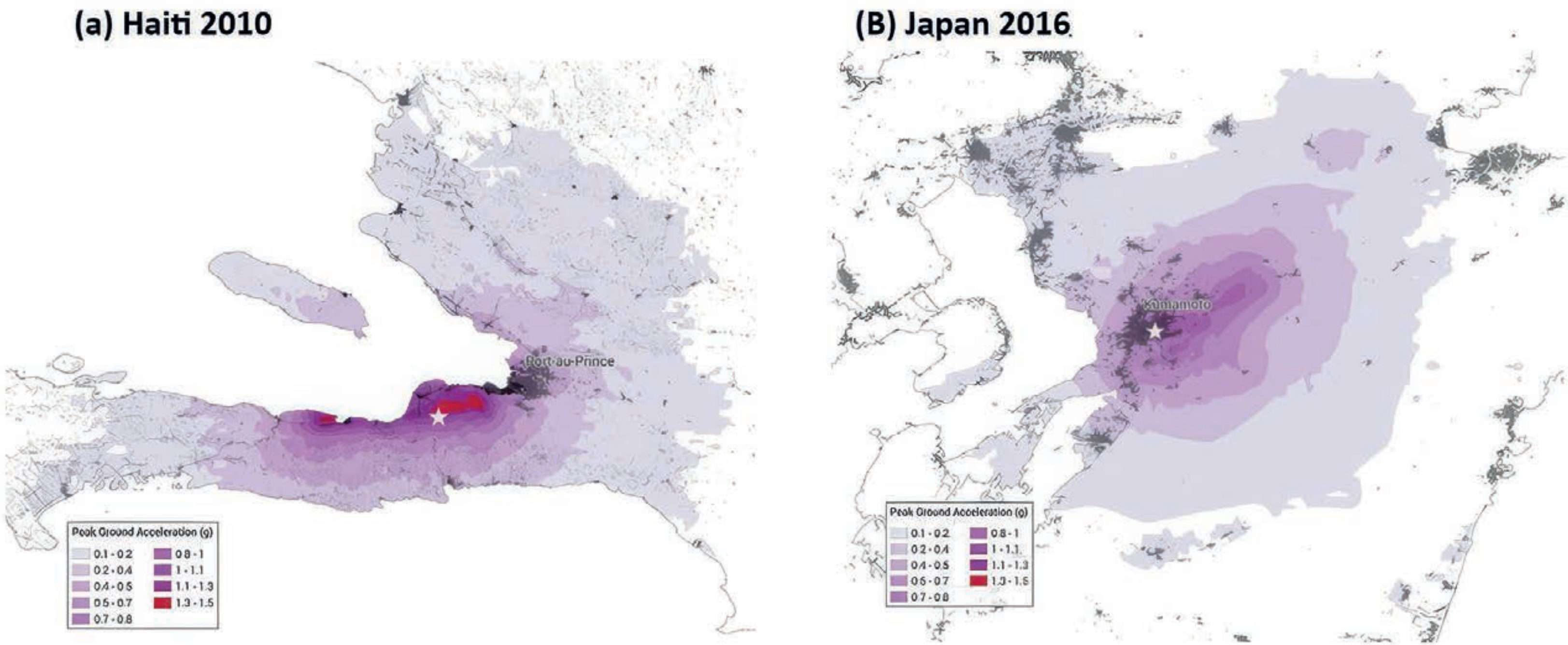
Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.

A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

Exposure and vulnerability to earthquakes are a function of seismic risk, which may be exacerbated by planning and investment decisions. As illustrated in Map 9, two similar seismic events can result in markedly different fatality rates. While the 2010 earthquake in Haiti and the 2016 earthquake in Kumamoto, Japan, had similar magnitudes of around 7.0, their impacts were starkly different, despite affecting comparably sized populations. In Haiti, over 200,000 lives were lost, millions were displaced and much of the country's vital urban infrastructure was destroyed. Conversely, in Japan, the Kumamoto earthquake resulted in approximately 50 fatalities, significantly less damage and fewer displaced individuals.

Map 9. **Comparison of earthquake impact in Haiti (2010) and Japan (2016)**



Source: GEM Foundation, 2024

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Region	East_Asia	Caribbean_Central_America
Country	Japan	Haiti
Event name	Kumamoto_2016	Haiti 2010
Local date	16/04/16	01/12/10
Mw	7	7
Max intensity_(MMI)	IX	IX
Fault mechanism	Strike slip	Strike slip
Tectonic region type	Active Shallow Crustal	Active Shallow Crustal
Fatalities	50-228	158,679-316,000
Injured people	1,500-2,753	300,000
Displaced population	23,985-196,000	1,269,110-1,800,000
Affected population	272,763	3,000,000-3,700,000
Damaged units	189,939 Units	285,677-317,289
Collapsed units	8,697 Units	105,000-188,383
Economic losses (USD)	20,000-22,580 M (<1% GDP)	7,000-8,000 M (>70% GDP)

Japan's proactive investments in seismic design, resilient construction, insurance coverage and public risk awareness significantly reduced the impact of the Kumamoto earthquake. These achievements were underpinned by the country's relative wealth and strong governance frameworks and its investments in joint planning and increasing resilience, such as improving and enforcing land-use planning, undertaking slope stabilization and other public works. These interventions take time and require investment, including in skills development at the local level, but they reap long-term benefits.

By contrast, Haiti's experience highlights the devastating consequences of weak risk mitigation and the pivotal role that governance challenges, limited technical capacity and acute poverty can play in turning hazards into disasters. In the absence of robust regulatory systems to enforce safe building standards and with under-resourced institutions unable to plan and deliver emergency relief, the earthquake quickly escalated into one of the most severe humanitarian crises in recent memory.

The lessons from Japan offer a valuable model for other countries vulnerable to earthquakes. Where finance is available, countries like the Dominican Republic are accelerating the adoption of seismic resilience standards in both new construction and retrofitting, as outlined in Box 8.

Box 8. Seismic risk assessment and retrofitting of schools in the Dominican Republic

Latin America and the Caribbean is the second-most disaster-prone region in the world, after Asia and the Pacific. On 1 February 2023, a magnitude 5 earthquake, measuring 5.3 on the Richter scale, damaged six schools in the Province of Peravia in the Dominican Republic. Just five months earlier, the national seismic risk and infrastructure safety office had warned that about 1,200 of the country's schools were built on earthquake fault lines.[3]

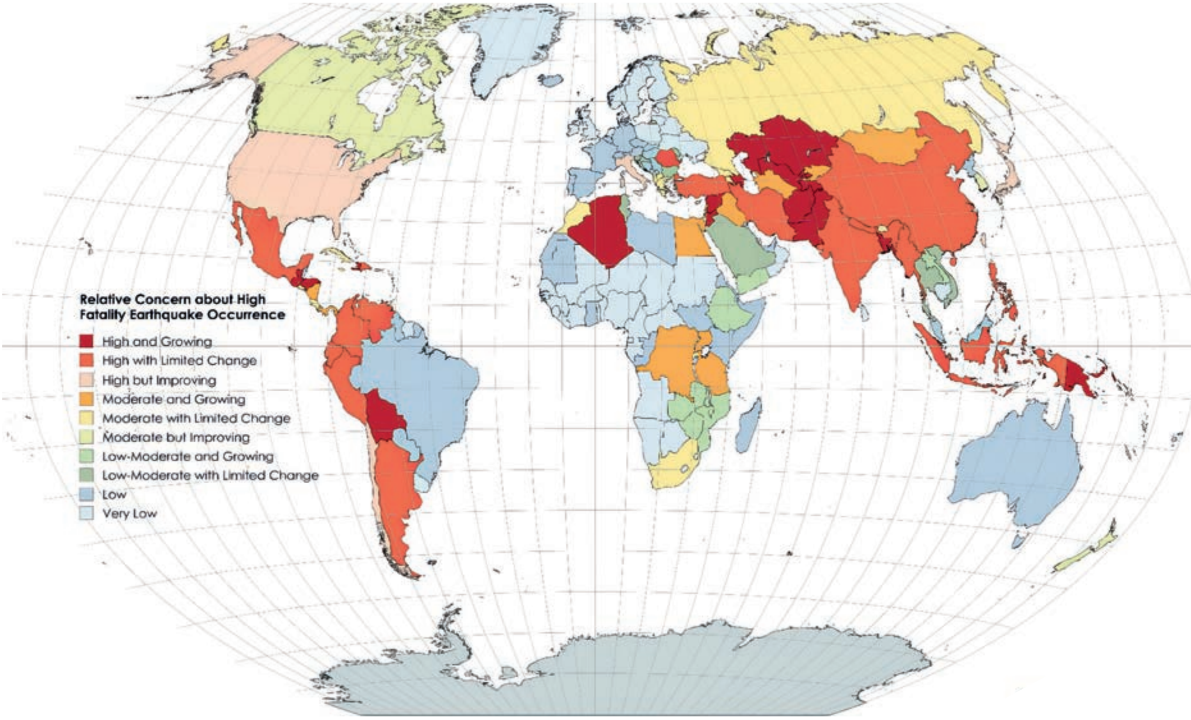
To strengthen preparedness, the United Nations Educational, Scientific and Cultural Organization (UNESCO), as part of a Disaster Risk Reduction (DRR) project launched in 2020, had trained local students of engineering and architecture in the Dominican Republic on how to assess the earthquake vulnerability of schools and correct the problem through retrofitting and other measures. The first step was to identify and rectify vulnerabilities in existing school structures, such as a fissure along a bearing wall or a lack of early warning systems. The inspectors identified risks and retrofitting opportunities at 85 schools across five municipalities in the Dominican Republic. They conveyed these findings to the local and national governments so that they could allocate targeted resources to fortify only those constructions in need of retrofitting. It is estimated that in an alternative scenario in which the Dominican Republic implemented comprehensive retrofitting of schools, roads and bridges, the recovery time would shrink to 79 days, thanks to the retrofitted infrastructure, which would cost just $8 per pupil.[4]

UNESCO consultant and civil engineering students undertake virtual risk assessment at La Vega school in the Dominican Republic.

Credit: UNESCO

However, there is still much to do. Map 10 looks across the disaster risk equation at hazard, exposure and vulnerability to estimate where the world faces the highest risk of a major fatality earthquake. Action taken now to build earthquake risk resilience could prevent thousands of deaths in future decades.

Map 10. Relative level of concern about a high-fatality earthquake (5000 or more deaths) occurring in each country, with risk trend



Source: Adapted from the Global Earthquake Model's Global Seismic Hazard (Johnson et al. 2023) and Risk (Silva et al. 2023)

The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

A lack of resilience investment and finance is often cited as a key barrier to seismic resilience, and improved approaches to investment will be required to address the seismic inequalities in the map above. This topic is a key concern in later chapters of this report. However, the case study of Colombia (Box 9) provides a clear example of a high-risk developing country successfully deploying a combination of public and private investment tools to incentivize seismically resilient construction, thereby saving lives and protecting the livelihoods of many poor households.

Box 9. The power of collective urban insurance in Manizales, Colombia

Manizales is the capital city of Caldas, a department that lies on the Colombian Central Mountain Range of the Andes. Founded in 1849, Manizales is built on ridgelines and steep slopes, where soil instability, heavy seasonal rains and seismic activity have necessitated major public works and urban planning measures, including land use regulations, building codes and watercourse management. These efforts have earned the city recognition as a model of good practice in disaster risk management.[5] This achievement has been supported by a strong alliance between academia, local government, the regional environmental authority and utility providers, working within a solid regulatory framework and alongside a well-informed, politically engaged population.[6]

Alongside these risk mitigation efforts, the city has also implemented an innovative insurance programme. The Mayor's Office designed and developed, with the support of the Manizales Branch of the National University of Colombia, a catastrophic risk assessment map for earthquakes and landslides. Based on this study, the city designed and implemented a collective voluntary insurance policy to cover the poorest strata of the city. After five years, the design of the financial instrument was refined based on performance studies involving public and private entities, the university, the national planning office and the World Bank.[7]

The insurance subscription is voluntary: when the property tax payment is made, each householder decides whether or not to include the insurance premium charge. Urban and rural properties whose assessed valuation is below a minimum threshold, corresponding to around 20% of the total number of properties and around 4% of the insurable value, are exempt from paying property tax.[8] The annual premium agreed with the insurance company was calculated based on the value of each property, with a deductible of 3% of the value of the loss in the event of an earthquake. In the case of other natural phenomena or events such as strikes, riots, uprisings, civil or popular unrest, malicious acts by third parties or terrorism, the deductible was agreed at 10% of the loss of the affected property.[9] The low-income homeowners' segment receives the social benefit of the risk transfer mechanism through a cross-subsidy strategy. Besides promoting a stronger insurance culture, it also enhances the solidarity of the community.[10]

Cityscape of Manizales, Caldas, Colombia

Credit: Shutterstock, Jess Kraft

Buffering against floods and storms

Between 1970 and 2019, water-related hazards accounted for 50% of all disasters and 45% of all reported deaths from disasters.[11] Since 2000, the number of recorded flood-related disasters has risen by 134% compared with the two previous decades. Floods and storms are responsible for a range of often unaccounted indirect impacts to people and the planet, destroying ecosystems and driving disaster-related displacement. The number of people exposed to floods globally has also steadily risen from 28.1 million in 1970 to 35.1 million in 2020, an increase of 24.9%. Most flood-related deaths and economic losses are recorded in Asia.[12]

Floods and storms also affect education outcomes, particularly among marginalized populations.[13] This can occur directly, due to the temporary closure or even destruction of education infrastructure, injuries and loss of life among students, parents and school staff or indirectly due to related disaster impacts such as displacement, loss of livelihood and illness.[14] Addressing these education-related impacts requires strengthening local disaster preparedness, particularly in high-risk countries like Bangladesh, where community-based initiatives are helping close critical capacity gaps as outlined in Box 10.

Box 10. Training local communities in Bangladesh to boost flood preparedness

Bangladesh – July 25, 2020: A woman from the village is carrying wet jute on her shoulder to dry at flood-affected areas Rajrajeshor, Chandpur, Bangladesh.

Credit: Shutterstock, Jahangir Alam Onuchcha

Bangladesh is among the world's most disaster-exposed countries, with millions at risk from flooding and other hazards. To help reduce flood risk, Practical Action and the Village Education Resource Center partnered to improve early warning systems, build local capacity and strengthen links between communities and local authorities.

Consultations with these groups revealed significant resource and knowledge gaps, particularly within Union Disaster Management Committees (UDMCs), the main rural disaster bodies under Bangladesh's Standing Orders on Disasters (2019). Many UDMCs lack the training, funding and capacity to function effectively, leaving communities vulnerable.

To address this, the programme trained community members to become "local resilience agents" (LRAs) in disaster preparedness and risk reduction. LRAs support UDMCs by bridging the gap between communities and local authorities, helping to coordinate emergency relief, distribute supplies like seed and fertilizer and deliver timely flood warnings. They also share practical advice on farming practices based on weather forecasts.

By improving access to critical information, LRAs help communities take anticipatory action to manage risks more effectively. Their training covers key topics such as first aid and search and rescue, enabling them to assist in disaster response. As trusted figures, they are well-positioned to identify local needs, access resources, and advocate for community priorities, including women's rights and protection from gender-based violence. Their leadership often inspires others to become more engaged in resilience-building efforts.

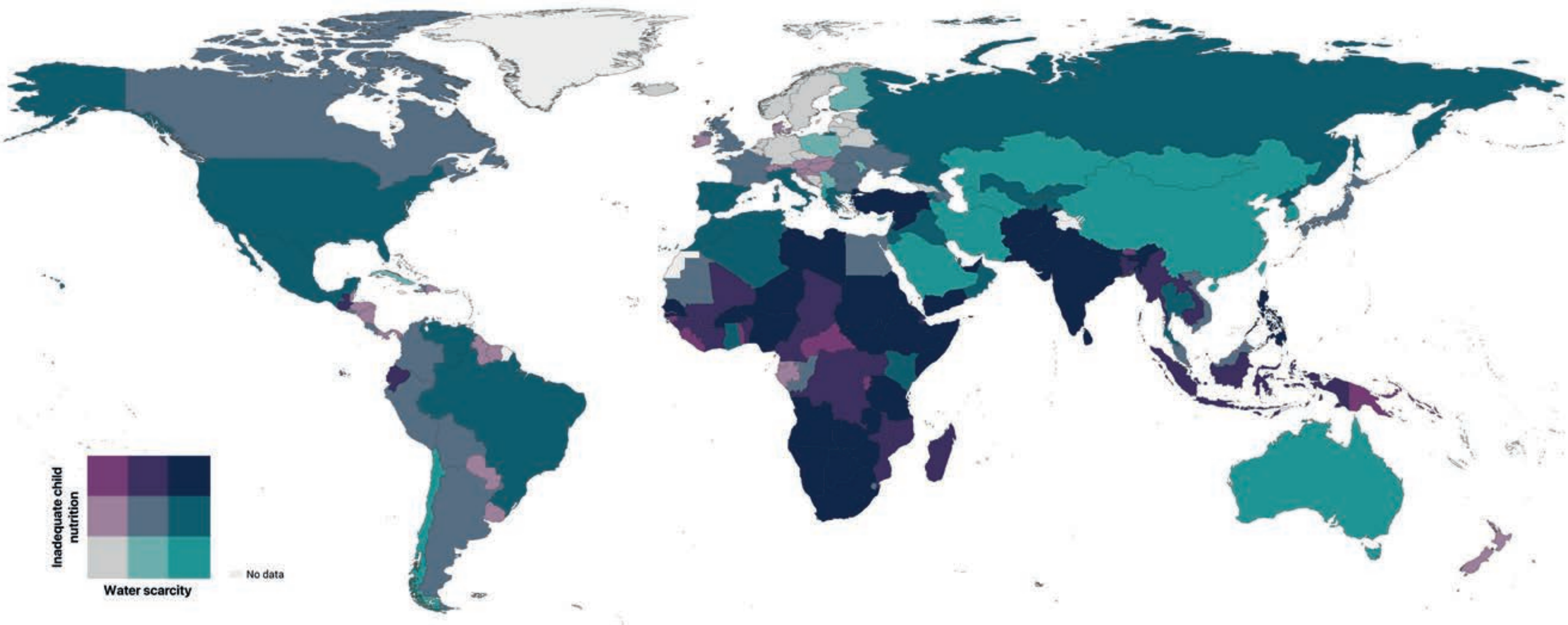
Source: Climate Resilience Alliance

Combatting drought and water scarcity

Like floods, droughts are also widespread and affect countries in every region. In the decade to 2017, drought affected at least 1.5 billion people and cost $125 billion globally. Recorded droughts have increased by 29% over the past 20 years. Since 2000, most drought-related deaths have occurred in Africa.[15] Droughts often have a range of indirect impacts, such as increased water scarcity, with significant direct and indirect impacts on human and planetary wellbeing.

These impacts are especially acute for marginalized groups, including children. As of 2025, over 920 million children (over one-third of the global child population) were highly exposed to water scarcity, impacting their nutritional access.[16] Map 11 draws on data from the Children's Climate Risk Index to illustrate the relationship between water scarcity and inadequate child nutrition. Children who lack adequate nutrition are more susceptible to severe diseases, impairing physical and cognitive development and are more susceptible to conditions such as stunting and wasting. Currently, Africa and Asia demonstrate the most extreme impacts, and without risk reduction action, vulnerability will be intensified by climate change.[17]

Map 11. Global water scarcity and its impact on child nutrition (2021)



Source: Data: UNICEF (2021), The Climate Crisis is a Child Rights Crisis: Introducing the Children's Climate Risk Index. Cartography: GEM Foundation, 2024

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

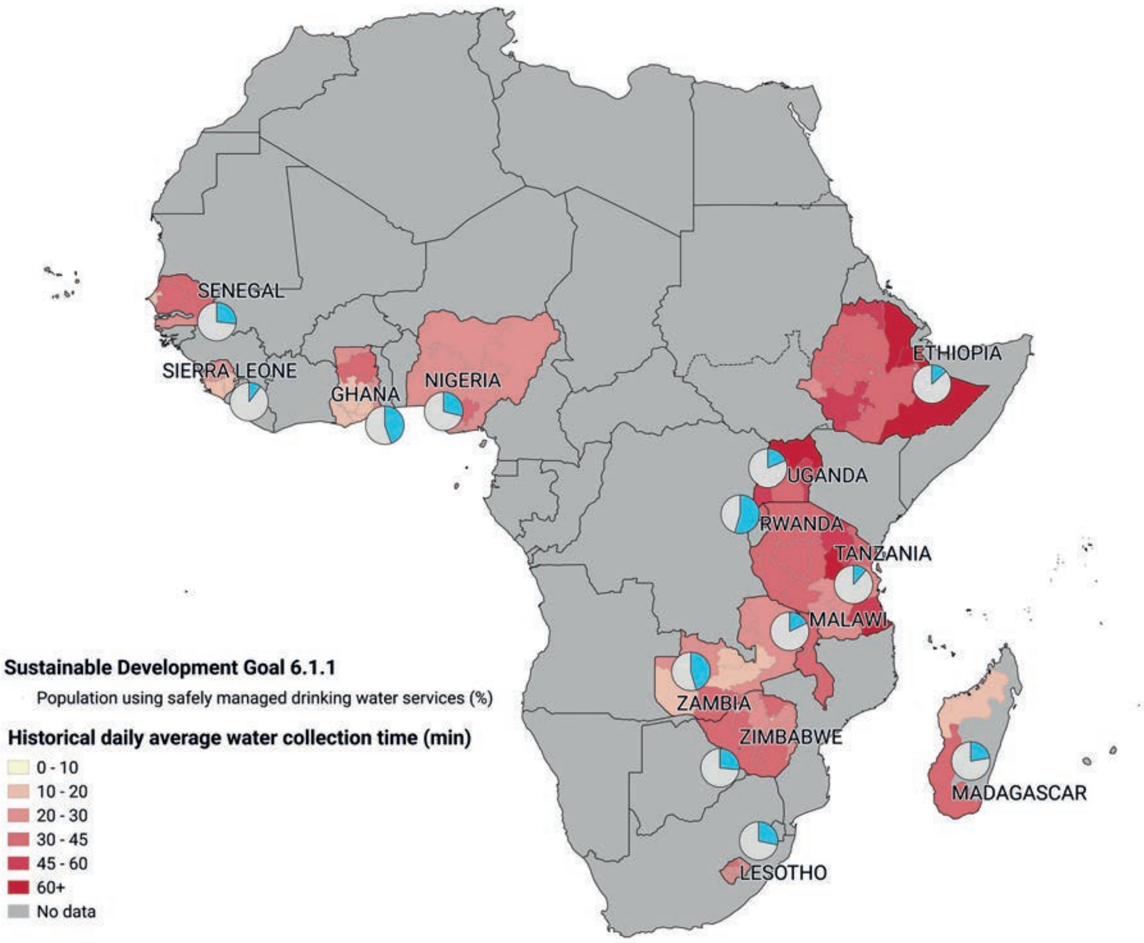
Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.

A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

Water scarcity in many parts of the world is also associated with a decrease in women's wellbeing. For instance, Map 12 shows the historical (1990-2019) daily average water collection time for women in households without on-site water access at the local level across Africa. Daily water collection times can exceed 60 minutes in parts of Ethiopia, Tanzania and Uganda (Map 12). These countries also report very low rates of access to safe drinking water services, with just 10-20% of the total population covered. Rising temperatures are expected to exacerbate this global burden of water collection further.[18] However, the impacts of water scarcity can be significantly reduced by disaster risk reduction action, investments that deliver a range of additional benefits (Box 11).

Map 12. **Daily water collection time for women without on-site supply, 1990–2019**



Source: Data:Carr et Al., 2024.
Cartography: GEM Foundation

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.

Box 11. Building resilience through investment in water security in Madhya Pradesh, India

Less than a decade ago, the community in Kapoti village was struggling to fulfil its water needs. The village had no facility for safe drinking water - no wells, handpumps or piped water supply, meaning the area's natural springs were the only source of water available for consumption. The water was used for drinking, and all other activities like washing clothes, utensils, bathing and livestock farming. These activities contaminated the spring water and led to rampant waterborne diseases, including a cholera outbreak that caused several deaths in the village. This urgent crisis led to a collaboration between the community (traditional leaders), panchayat (local government) and civil society organizations (CSOs). The aim was to identify affordable solutions to provide clean drinking water to the village.

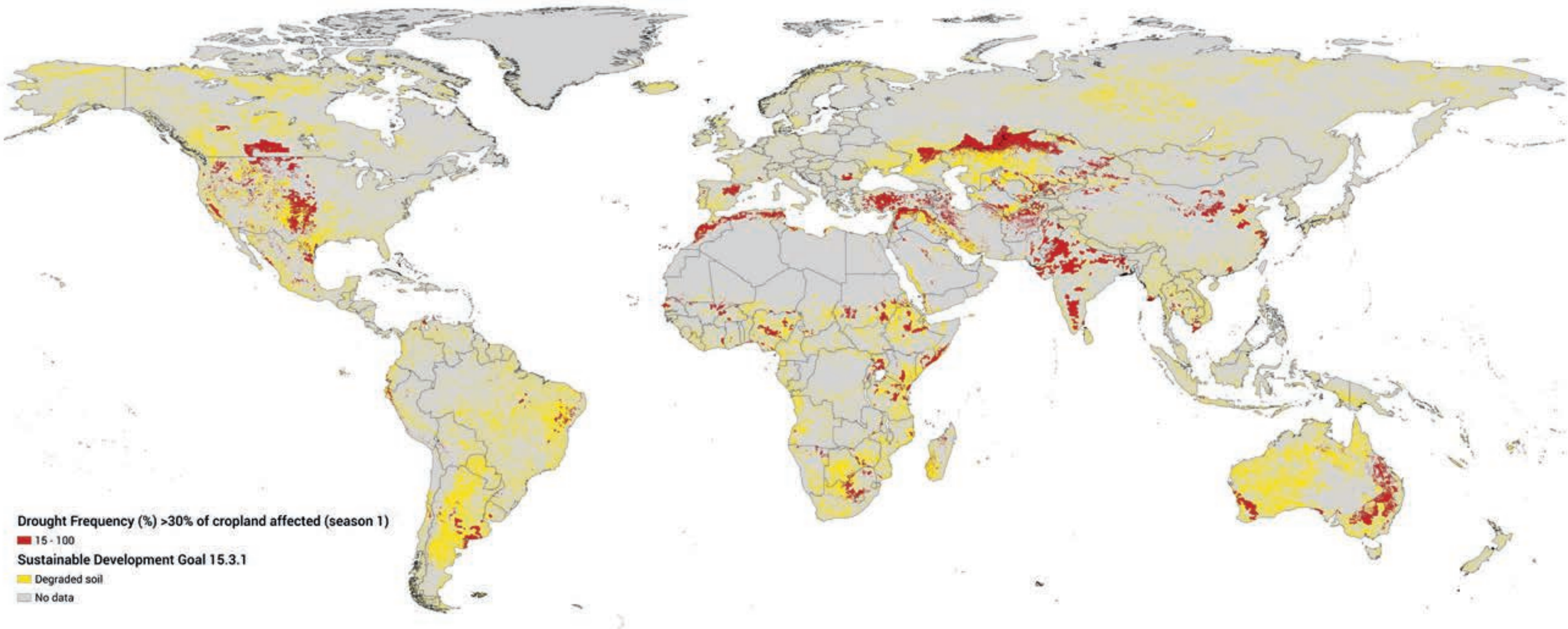
In addition to external investment, the local community contributed 10% of the project's cost in cash and kind. This committee now collects A tariff per household annually, which keeps records of finances and repair works. The whole system is managed sustainably by the community itself. This reliable water supply, besides contributing to a sharp decline in waterborne diseases, has also granted the villagers more time for livelihood activities, education and leisure. With access to drinking water, schools and childcare centres are fully functional, and the school dropout rate among girls has decreased. The use of household toilets has also improved the village's WASH standards.[19]

Reducing the risk of desertification and soil degradation

Agriculture is the most vulnerable economic sector to adverse climate impacts. Some 82% of all damage and loss caused by drought was borne by agriculture in low- and lower-middle-income countries between 2008 and 2018.[20] Meteorological drought does not always lead to agricultural drought, which depends on factors like the timing and amount of rainfall during the crop season, and how well the soil retains water. Drought causes short- and medium-term water livestock and crop shortages (including fodder), lowering yields and ultimately threatening food security. In the case of prolonged or recurring droughts, longer-term impacts can transpire, such as land subsidence and seawater intrusion along river systems with reduced water flow.

Map 13 shows the frequency of severe drought in areas where at least 30% of cropland was affected during the first crop season between 1984 and 2023. The highest frequencies of severe drought were concentrated in the central United States, Argentina, Turkey, northwest India, Pakistan, the Horn of Africa, Central Asia, northern Morocco and New South Wales in Australia. These regions experienced approximately eight to 12 severe agricultural drought events over the 40-year period. Much of the variation in drought extent and the impact on global cereal production can be attributed to El Niño and La Niña phases and strong and very strong El Niño events.[21]

Map 13. Agricultural cropland severely affected by drought and degraded soil (season 1, 1984–2023)



Source: Data: FAO - Agricultural Stress Index System (ASIS), 2023 and UNSD 2015 (SDG 15.3.1). Cartography: GEM Foundation

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

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A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

Better drought management can reduce the risk of land degradation and topsoil loss and provide significant long-term food security benefits. Actions such as enabling anticipatory action planning can help buffer the most vulnerable communities from recurrent drought risk and protect the livelihoods of the most vulnerable communities, as outlined in Box 12.

Box 12. Addressing drought in the Dry Corridor of Central America through collaborative anticipatory action

For the first time in 2024, anticipatory action (AA) was activated for two consecutive agricultural seasons in the Dry Corridor of Central America.[22] Implemented in Honduras, Guatemala, El Salvador and Nicaragua with pre-assigned funding, this initiative was tailored to each country's context through collaboration between governments and international agencies. Governments played a critical role in facilitating early warnings, coordinating responses and integrating AA into legal frameworks, with agricultural, disaster risk management and meteorological institutions at the national and municipal levels contributing to the process. Various international organizations, including the Food and Agriculture Organization of the United Nations (FAO), World Food Program (WFP), the German Red Cross, United Nations Office for the Coordination of Humanitarian Affairs (OCHA), United Nations Children's Fund (UNICEF) and The World Health Organization (WHO), assisted in the development of these programmes.

Crucially, agroclimatic data and early warning systems allowed interventions to be activated ahead of drought, ensuring timely support. The system anticipated the El Niño-induced drought's impact on Primera and Postrema harvests, enabling early interventions that mitigated the worst effects and protected livelihoods and food security. Protective measures, including cash transfers and agricultural inputs, were distributed before the full onset of drought, stabilizing food security. Studies in the four countries showed a return of up to $4 per $1 invested, demonstrating the cost-effectiveness of the AA approach. It also strengthened community resilience by activating preventive measures early and building local capacities to better cope with future droughts and climate shocks.

Ensuring the sustainability of effective AA in the Dry Corridor depends on continued government leadership, coordination and integration of AA strategies into national legal frameworks, with appropriate allocations from public budgets to finance their implementation.[23]

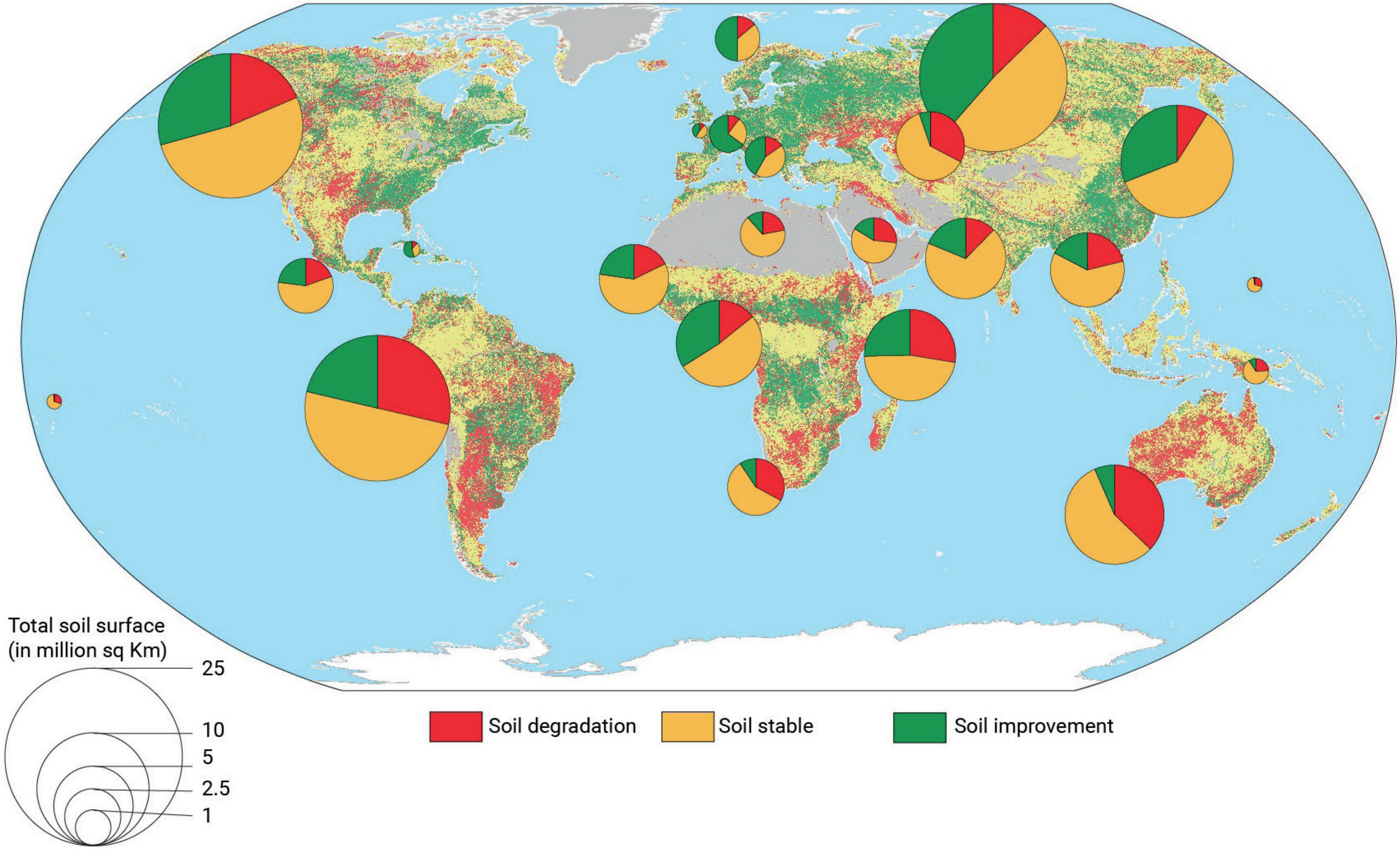
Sonsonate, El Salvador - January, 3rd 2011: A local farmer uses the traditional method of plowing the land with an ox cart.

Credit: Shutterstock, Guayo Fuentes

Rates of soil erosion are estimated to have worsened over the past decade, partly due to factors related to climate change.[24] Map 14 illustrates that soil degradation – including erosion, loss of fertility and structural breakdown – poses significant global risks to food security, water quality and biodiversity. Mismanagement of soil resources has led to widespread land degradation, affecting approximately 30% of the world's land area.[25] At a global level, it reduces agricultural food production by 33.7 million metric tons every year.[26]

The financial consequences are profound, with annual global costs estimated at $300 billion, impacting agriculture, infrastructure and ecosystem services.[27] Effective soil management and restoration can mitigate these risks, offering substantial economic and environmental benefits.[28]

Map 14. Global soil degradation between 2001 and 2015



Source: Data: Global land Degradation between 2001 and 2015 (SDG 15.3.1).
Generated by UNEP/GRID-Geneva, based on Trends.Earth model. Cartography: GEM Foundation

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Planning to reduce extreme heat impacts

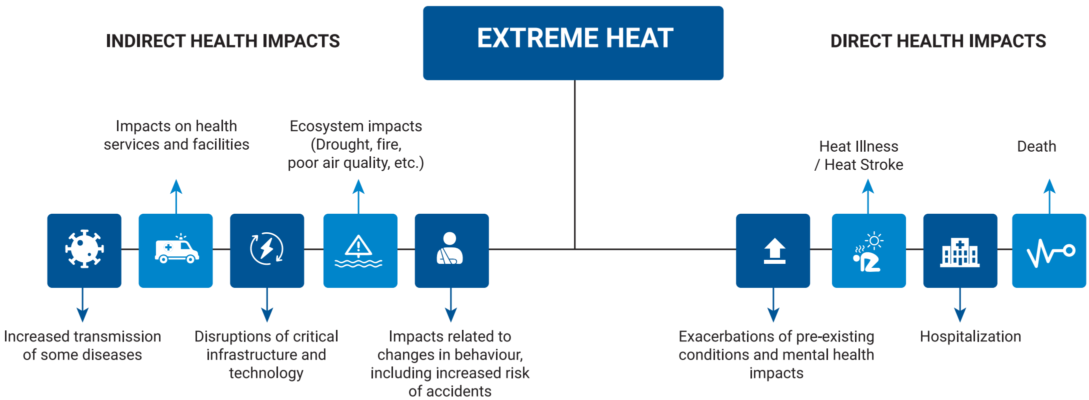
Extreme heat, which causes fatalities, productivity losses and lower wellbeing, is now recognized as one of the "big five" hazards. In recent years, extreme heat has become the leading cause of reported weather-related deaths. The number of people exposed to extreme heat is growing in all world regions, with deadly implications: heat-related mortality for people over 65 years of age increased by approximately 85% between 2000–2004 and 2017–2021.

Between 2000 and 2019, studies show that approximately 489,000 heat-related deaths occurred annually, with 45% of these in Asia and 36% in Europe. Of these, an estimated 61,672 heat-related excess deaths occurred in the summer of 2022 alone. This high-intensity extreme heat event was not unprecedented: around 70,000 people died in Europe during the summer months of 2003. In 2010, 56,000 excess deaths occurred during a 44-day heatwave in the Russian Federation.[29]

Many heat action plans remain focused on response rather than transformation, with limited emphasis on reducing risk before extreme heat events occur. Compounding this challenge, many countries still do not recognize extreme heat as a disaster, leading to significant underreporting and masking the true scale of its impacts.

Figure 22 illustrates some of the direct and indirect impacts of extreme heat on human health. It highlights that heatstroke is a medical emergency that can be fatal. Extreme heat also exacerbates underlying illnesses, including cardiovascular disease, diabetes, poor mental health and asthma, and can increase the risk of accidents and transmission of some infectious diseases.

Figure 22. **Direct and indirect impacts of extreme heat on human health**



Source: WHO Team Climate Change and Health (CCH), Environment, Climate Change and Health (ECH) (2024)

Extreme heat is also a serious environmental hazard and a major risk to people's health at work, putting around 2.4 billion workers, 70% of the planet's working population, at risk.[30]

The effects of rising temperatures and extreme heat are more acutely felt in urban centres. The urban heat island effect refers to the phenomenon wherein metropolitan areas are warmer than their rural surroundings. It is the result of several interrelated factors, including, but not limited to:

- Urban canyons: reduced ventilation, wind blocking and trapped heat caused by the proximity of tall, compact buildings
- Urban deserts: diminished blue spaces, green cover and vegetation, meaning less natural shade and cooling benefits
- Concrete jungles: the use of heat-trapping materials like concrete and asphalt in large quantities

- Waste heat: heat generated by human activities like air conditioning, transport and industrial processes

Changing investment and planning patterns can reduce or prevent each of these factors, preventing heat escalation, improving wellbeing and reducing a range of associated costs. Encouragingly, many cities around the world are stepping up action to reduce the risk of heat-related disasters. In Skopje, North Macedonia, a Soviet-era shopping centre that had become a mini heat island has been retrofitted to reduce ambient temperatures and create a popular new urban park (Box 13).

Box 13. Investing in green infrastructure in Skopje, North Macedonia

Throughout the summer of 2024, North Macedonia suffered prolonged heat waves and devastating forest fires, with temperatures in the capital, Skopje, recording a peak temperature of 42.7°C in mid-August. In response, with United Nations support, the municipal authorities drew up a comprehensive thermal map of the city to accurately detect the location of heat islands in the city. As a result, over 70 measures have been prioritized, ranging from increasing tree and vegetation cover to installing green or cool roofs and improving ecological urban planning practices.

The city's shopping centre proved to be one of the hottest spots on the map, with temperatures on average 9°C higher than those measured on the city square. Public funds were invested to transform the roof of the building into a new and unique 1,600 m² green space, whose maintenance costs are then left to the building's private owners. By vegetating it with almost 3,700 plants of varying sizes and equipping it with a special irrigation system, this intensive green roof project enhances the resilience of its surroundings and brings an array of benefits. Besides mitigating the threat of extreme weather conditions such as heat waves, improving stormwater management by reducing runoff, and filtering air and noise pollution, it also helps to sequester carbon, improve the building's energy efficiency and increase biodiversity by creating new ecosystems for living organisms.

The innovative design features several elements that support these outcomes, including a "Sedum carpet" of dense plants covering an area of 150 m² and soaking up CO2 from the air. Meanwhile, "vertical gardens" of around 54 m² are expected to capture around 2.3 kg / m² of CO2 from the air annually and lower the temperature by 3°C by absorbing around 50% of the solar radiation. Additional features such as fountains, paved paths, amphitheatre stairs and a chess court were added to make it an inviting space for residents to rest and relax, revitalizing the local neighbourhood. Thermal mapping also provided comparable results for the roof of the Koco Racin cultural centre in the city's downtown, where a similar public-private green roof scheme was developed over a total surface area of almost 400 m².[31]

Aerial view of the Old Bazaar in Skopje

Credit: Shutterstock, Leon Djingo

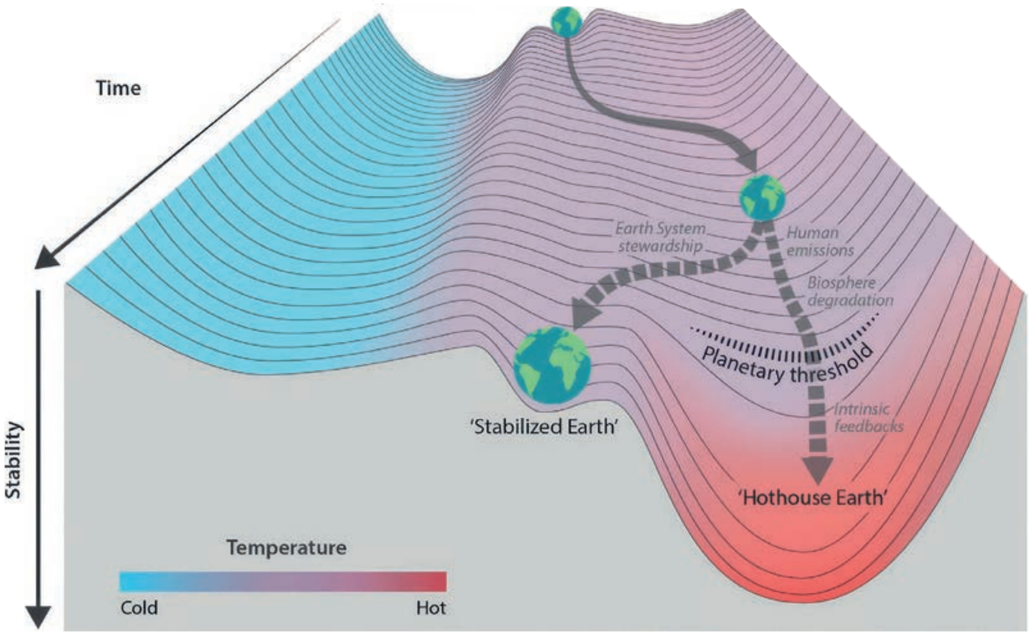
The benefits of reducing volatility in planetary systems

Global biodiversity loss has put an estimated 1 million species at risk of extinction,[32] and land degradation is expanding by about 1 million km² worldwide annually.[33] Breakneck development and soaring consumption levels are also driving instability, with over 2 billion tonnes of municipal solid waste generated annually.[34] The growth in the unsustainable use and consumption of natural resources, both renewable and non-renewable, results in the release of greenhouse gas emissions and the generation of increasing amounts of poorly managed household, industrial and human waste.

A tipping point happens when a given socioecological system can no longer buffer risks and provide its expected functions, after which the risk of catastrophic impacts to these systems increases substantially.[35] Tipping points occur when such intersecting pressures reach a point where a system drastically changes, with unpredictable and cascading effects.[36] These tipping points apply to both ecological (a coral reef, for example) and man-made (such as a supply chain) systems.

In an interconnected world, when tipping points are reached, impacts are often felt globally, causing ripple effects through food systems, the economy and the environment. They affect the very structure of society and the wellbeing of future generations, and they undermine our ability to manage future risks.

Figure 23. **Tipping points in Earth's system**



Source: Adapted from Mulhern (2020)

For example, people rely on groundwater to mitigate half of the agricultural losses caused by drought. If the reserves in aquifers continue to deplete, this may cease to be an option.[37] Groundwater aquifers supply drinking water to over 2 billion people, and around 70% of withdrawals are used for agriculture globally.[38] However, more than half of the world's major aquifers are being depleted faster than they can replenish naturally.[39] As groundwater accumulates over thousands of years, it is a non-renewable resource. The tipping point in this case is reached when the water table falls below a level that existing wells can access. Once crossed, farmers will no longer have access to groundwater to irrigate their crops. This puts farmers at risk of losing their livelihoods and can lead to food insecurity, putting entire food production systems at risk of failure. Measures can be taken to dig deeper wells at great cost, but this only delays rather than prevents when the tipping point is reached.

This is not a hypothetical threat. Some regions, like Saudi Arabia, have already surpassed this tipping point. In the mid-1990s, Saudi Arabia was the world's sixth-largest wheat exporter, based on the large-scale extraction of groundwater for irrigation. Once the wells ran dry, Saudi Arabian wheat production dropped, forcing the country to rely on wheat imports. This tipping point affects aquifers the world over, from India to the United States.[40]

As discussed in more detail in later chapters, as tipping points occur, so does the cost of their impacts, threatening the ability to transfer risk with tools like insurance. For example, in the area of home insurance, the risk tipping point is reached when increasingly severe hazards such as storms, floods or fires drive up the costs of coverage until it is no longer accessible or affordable. Once insurance is no longer offered against certain risks, in certain areas or at a reasonable price, these areas are considered "uninsurable".[41] In Australia, for example, it is predicted that approximately 520,940 homes will be uninsurable by 2030, primarily due to increasing flood risk.[42] Once this point is reached, people are left without an economic safety net when disasters strike, opening the door to cascading socio-economic impacts in high-risk areas.

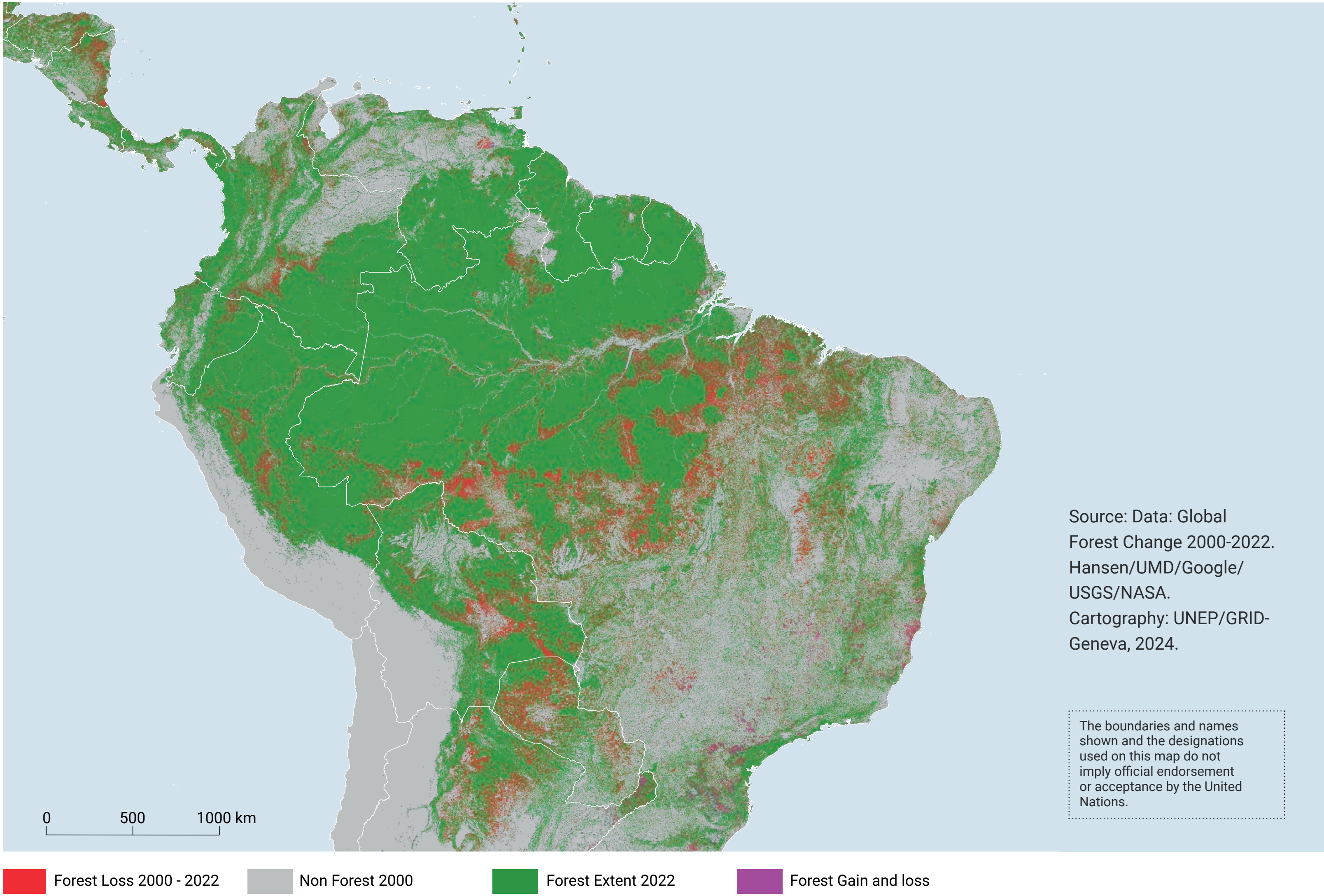
However, the impact of tipping points can still be avoided. Taking timely, preventative action can help stabilize fragile ecosystems and steer them away from collapse, laying a stronger foundation for sustainable development. The examples below highlight cases where ecosystems are under growing pressure, but targeted actions can help reduce instability and degradation, offering a more sustainable foundation for future development.

Protecting forests to stabilize micro-climates for farmers

One area where significant benefits can be achieved in disaster risk reduction is forest regeneration. Major forests such as the Indigenous forests in all nine Amazonian countries are a net carbon sink of 340 million tonnes of CO_2e/year, helping to moderate the global climate. In many parts of the world, these forests are being cleared, often to make way for cattle farming or other forms of agriculture. Deforestation reduces rainfall and increases the likelihood that fertile rainforest ecosystems will degenerate into less productive savannah ecosystems.

Deforestation results in reduced rainfall, higher CO_2 emissions and the irreversible loss of precious biodiversity. It also imposes massive productivity losses, worth $1 billion annually, on the region's agribusiness.[43] Policy choices today matter. For example, research suggests that productivity and associated revenue losses in the Southern Brazilian Amazon could cost $5.6 billion for soy and $180.8 billion for beef by 2050 under a weaker environmental governance scenario that abandons deforestation control. This dwarfs the conservation opportunity costs of $19.5 billion under a strong environmental governance scenario. Further deforestation of the Amazon forest could lead to a tipping point and change the ecosystem to savannah.

Map 15. **Deforestation and dieback of the Amazonian forests, 2000–2022**



Better forest management could help protect rainfall and stabilize local micro-climates for farmers, as illustrated by recent reforestation activities in Pakistan (Box 14). To achieve this, current investment incentives need to be significantly restructured to reflect the real value of the forest and the wide-ranging costs its destruction brings in its wake. With these in place, it should be possible for forests and human development to both prosper.

Box 14. The benefits of investing in reforestation: The Billion Tree Tsunami Afforestation Project in Pakistan

In recent decades, forest degradation and deforestation in Pakistan have led to more frequent flooding, elevated temperatures and worsening air quality, particularly through increased fine particulate matter. Nearly 10 million people in Pakistan are exposed to severe flooding each decade.[44] The 2019 Inform Risk Index ranks Pakistan as the fourth most exposed country to floods globally.[45] In 2013, the Khyber Pakhtunkhwa provincial government launched the landmark "Billion Tree Tsunami Afforestation Project" with the aim of planting 1 billion trees in the barren lands of the province, particularly the Hindukush Mountains, to counteract the extensive deforestation that had taken place during the previous 50 years. This project represented a long-term commitment to benefit future generations, with a range of expected impacts such as reduced vulnerability to flash and riverine floods, improved public health, enhanced conservation of natural resources and community participation.

As a result, forest cover in the project area increased from a mere 2% in 2010 to 35% by 2021, reversing a long-term decline that had seen coverage fall from 20% in 1990. The increased forest cover also reduced land surface temperatures. This remarkable reforestation effort was achieved through a combination of strategies, including planting new trees, banning illegal deforestation and engaging communities in forest management. The project contributed to a measurable decrease in mean temperatures and several socio-economic opportunities, including job creation and community involvement in sustainable forest management.[46]

The enchanting, mesmerizing, enticing, stunning, amazing, dazzling, glittering, alluring, fascinating, enthralling charming, captivating, beguiling and tempting valley of Ghizer district – commonly known as Phandar Valley

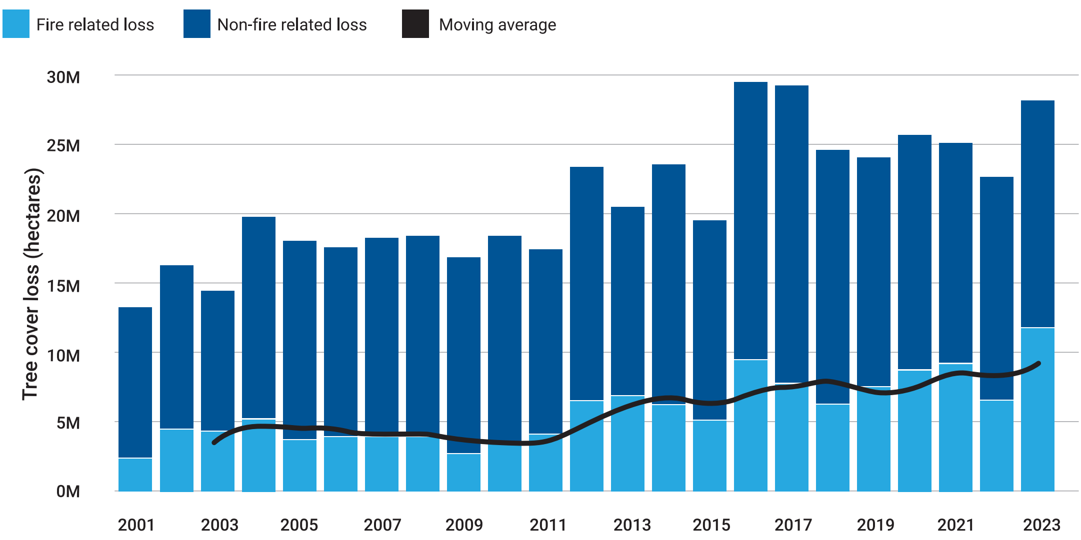
Credit: Muzaffar Bukhari

Reducing wildfires to protect people and the planet

Climate change is one of the major drivers behind increasing fire activity. Extreme heat events are already five times more likely today than 150 years ago and are expected to become even more frequent as the planet continues to warm. Hotter temperatures dry out the landscape and help create the perfect environment for larger, more frequent forest fires.

In terms of the environmental impacts of wildfires, the latest data confirm that wildfires are becoming more widespread, burning at least twice as much tree cover today as they did two decades ago.[47] Wildfires now result in nearly 6 million more hectares of tree cover loss per year than in 2001, an area roughly the size of Croatia. Fire also accounts for a larger share of global tree cover loss than other drivers, like mining and forestry. While fires only accounted for about 20% of all tree cover loss in 2001, they now account for roughly 33% (Figure 24).

Figure 24. **Tree cover loss due to fires compared to other drivers of loss, 2001-2023**

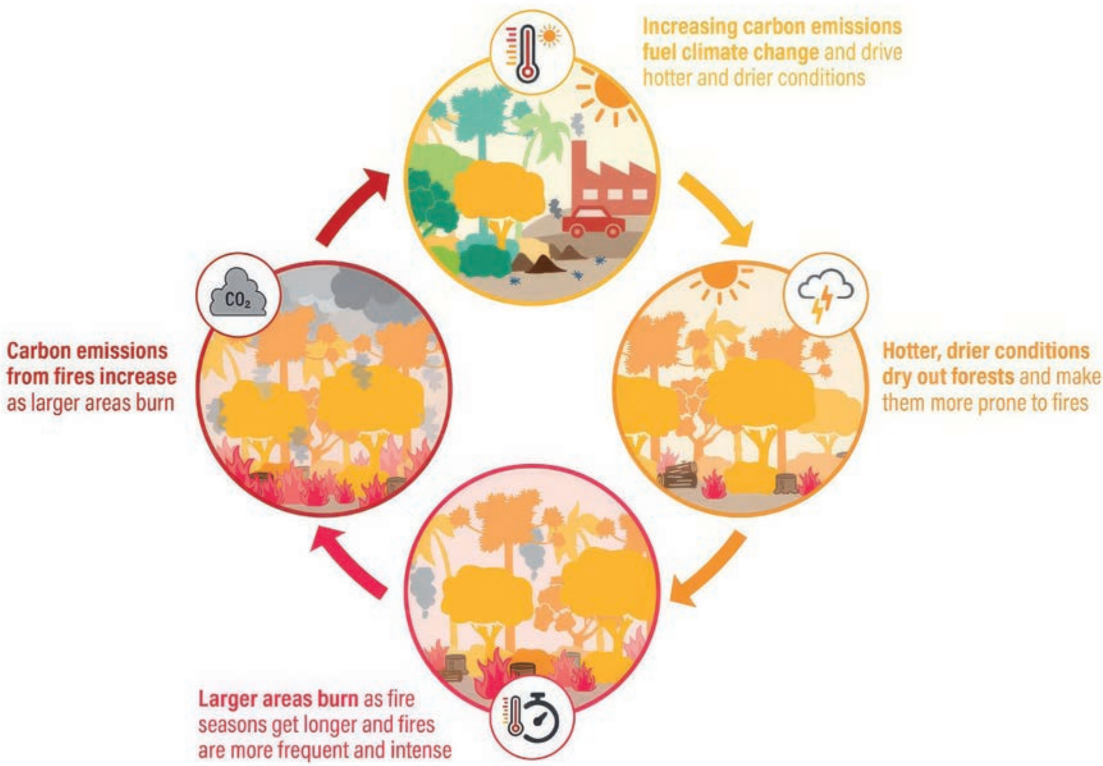


Non-fire related loss can occur from mechanical clearing for agriculture and logging, as well as natural causes such as wind damage and river meandering. The three-year moving average may represent a more accurate picture of the data trends due to uncertainty in year-to-year comparisons. All figures calculated with a 30 percent minimum tree cover canopy density.

Source: MacCarthy, (n.d.)

When forests burn, they release carbon stored in the trunks, branches and leaves of trees , as well as carbon stored underground in the soil. As forest fires become larger and more frequent, more carbon is emitted, further exacerbating climate change and contributing to more fires as part of a feedback loop (Figure 25).[48] These wildfires also harm air quality and biodiversity. Forests have deep cultural and societal value and have been home to many particular Indigenous Peoples for millennia. Fires also cause extensive environmental damage, including the destruction of habitats, loss of biodiversity and the release of greenhouse gases, contributing to climate change.[49]

Figure 25. **Fires and the climate feedback loop**

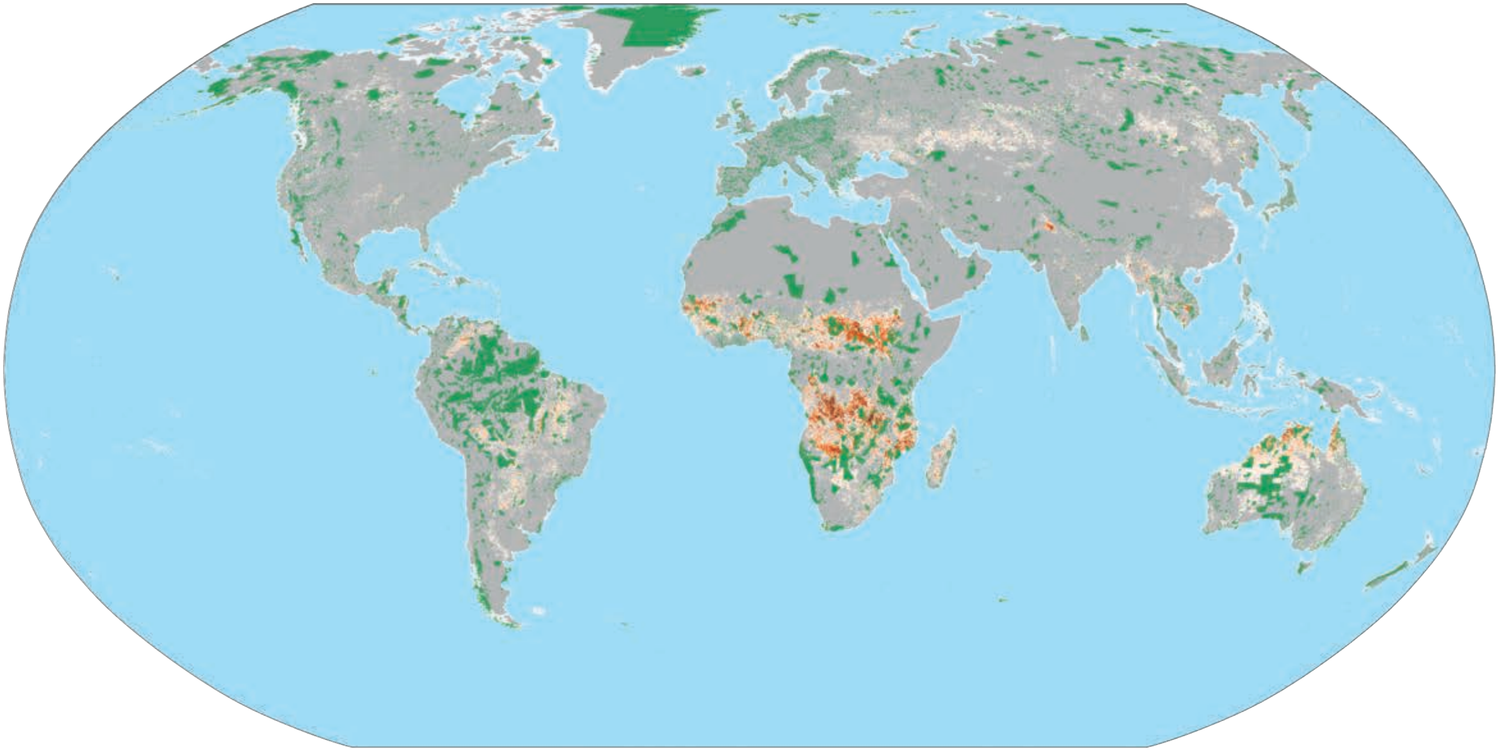


Source: Global Forest Watch

Map 16 shows the frequency of globally burned protected areas from 2003 to 2023, highlighting the impact of wildfires on protected areas.

The economic impacts of forest fires are equally severe, threatening homes and infrastructure and affecting sectors such as agriculture, forestry, tourism and public health. For instance, the costs related to fire suppression, loss of valuable timber and the decline in tourism due to damaged landscapes can be substantial.[50] Map 16 underscores the need for improved fire management strategies to protect vital ecosystems and mitigate the economic fallout from their destruction. As illustrated by the case of Banff National Park in Alberta, Canada (Box 15), fire prevention in protected areas is practicable and cost-effective

Map 16. Global distribution of burned protected areas, 2003–2023



Global distribution of burned area: number of events in 2003-2023 period

1 - 3 | 4 - 6 | 7 - 9 | 10 - 12 | 13 - 15 | 16 - 18 | 19 - 21

Terrestrial protected areas

Source: Data: NASA, 2021. Cartography: UNEP/GRID-Geneva, 2024.

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Box 15. Fire protection and restoration in Banff National Park, Alberta, Canada

Guided by the 2020 Fire Management Plan, Parks Canada has reintroduced prescribed burning to Banff National Park. By creating carefully controlled fires to remove potentially flammable material such as surface vegetation, this technique can help reduce the risk of a wildfire outbreak. Prescribed fire reduces the buildup of dense trees such as spruce and dead wood, opening up the forest and creating better growing conditions for buffalo berries, a critical food source for grizzly bears. It helps to maintain and restore native meadows and grasslands, creating better growing conditions for drought- and fire-tolerant species like Douglas fir and aspen.

A mosaic of habitat types can also limit the size of fires. While wildfires are difficult to suppress in dense pine stands, patches of open meadows and grasslands decrease the fire's intensity and provide areas where fires can be extinguished by fire personnel or rain more easily. Previously burned areas will also have less fuel available on the forest floor, further reducing the spread and growth of wildfire. It also means more usable space for wildlife, from pine martens to grizzly bears.

Source: Parks Canada (n.d.)

The Spreading Creek Wildfire 07-04-2014 close to the Saskatchewan River Crossing, Banff National Park, Icefields Parkway, Rocky Mountains, Alberta, Canada, July

Credit: Shutterstock, Freisein

Box 16. Measuring indirect disaster-related losses: Disability-adjusted life years (DALY)

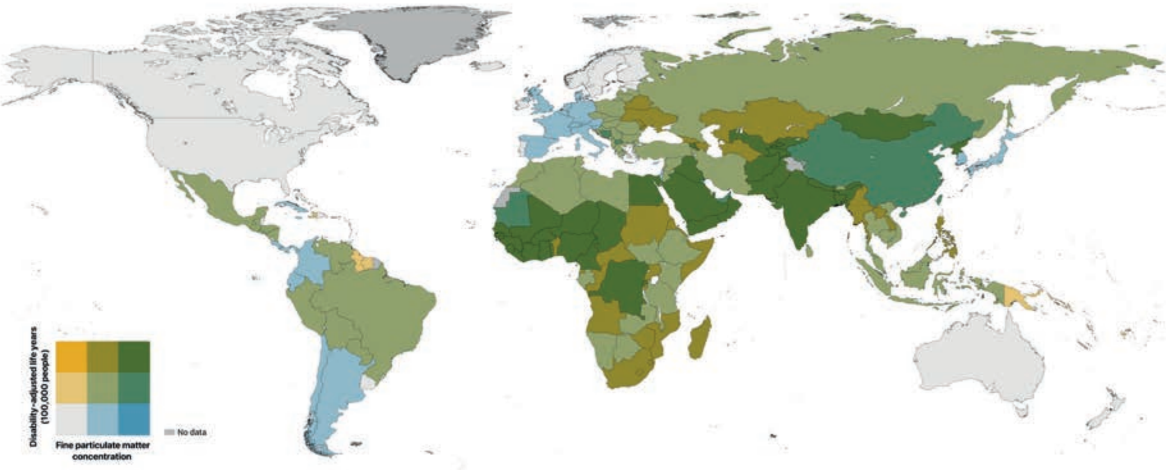
While the human costs of disasters are measured mainly in lives lost or affected, there have been efforts to measure the wellbeing and economic losses related to disasters expressed as “life-years lost”. This methodology builds on the disability-adjusted life year (DALY) approach used in public health to quantify the number of years lost because of diseases, disability, or early death. One DALY corresponds to a lost year of healthy life and is made up of two components – years of life lost due to premature mortality and years of life lived with disability.1 The DALY methodology can help quantify impacts of disasters on human lives, such as lost time in school, work time lost and lowered productivity and wellbeing.

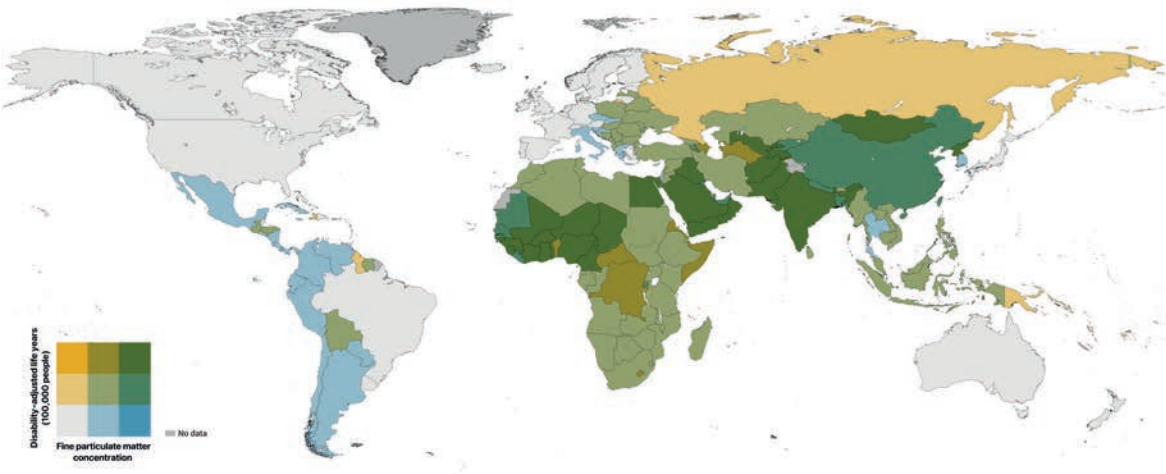
Improving air quality and human health

In many countries, wildfires are an often under-reported source of air pollution, even outstripping other sources like transport or industrial emissions at certain times of the year. While wildfires are not the only source of deadly air pollution, they contributed to the 4.2 million premature deaths caused by ambient (outdoor) air pollution recorded worldwide in 2019.[51] Of these, around 89% occurred in low- and middle-income countries, with the highest number in South-East Asia and the Western Pacific.[52]

Comparing the global distribution of fine particulate matter (PM2.5) and disability-adjusted life years (DALYs) in 2010 and 2019 reveals both progress and persistent challenges (Map 17). PM2.5 is a key air pollutant that poses significant risks to human health and the environment: high concentrations are most prevalent in regions with intense industrial activities, rapid urbanization and limited air quality regulations. DALYs, meanwhile, measure the overall burden of disease, combining years of life lost due to premature death and years lived with disability caused by illness or injury. DALYs are higher in regions where weak health systems coincide with environmental risk factors, such as air pollution, malnutrition or unsafe water. The highest risk levels are observed in regions such as the Middle East, Africa and South Asia. These areas face a compounded burden due to high pollution levels, dense populations and vulnerable healthcare systems. They also represent some of the most rapidly urbanizing locations, further concentrating risk.

Map 17. **PM2.5 concentrations and Disability Affected Life Years, 2010**





Source: Data: WHO, 2024.
Cartography: GEM Foundation, 2024.

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.

A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

As of 2019, only 1% of the world's population were living in areas where the WHO air quality guidelines levels were met. The combined effects of ambient and household air pollution are associated with 6.7 million premature deaths annually.[53] Air pollution is also one of the most significant environmental risks to child health. An estimated 4.2 million premature deaths are attributed to ambient (outdoor) air pollution. Indoor air pollution remains a challenge, as population growth has outpaced access to clean cooking. Around 2.1 billion people worldwide (around a third of the global population) still cook using open fires or inefficient stoves, which generate harmful household air pollution.[54] Some 89% of these premature deaths occur in low- and middle-income countries, and the greatest number in the WHO South-East Asia and Western Pacific Regions. Nearly 60% of deaths from household air pollution are among women and children who spend hours around sooty cookstoves burning wood, coal and kerosene.[55] Shifting to cleaner stoves can offer several benefits, such as reducing black carbon emissions and the time women and girls spend gathering fuel.[56]

Box 17. Switzerland's championing of clean air

Air quality in Switzerland has improved significantly over the past 25 years, and Zurich, the largest city, tops the list of European cities fighting air pollution. Notably, this has been achieved in ways that also mitigate climate change. Ambitious clean air policies have cut down on short-lived climate pollutants, including a 16.7% reduction in methane emissions between 1990 and 2015, due mostly to smart agricultural policies like manure management and efficient livestock production. Black carbon emissions also decreased by an impressive 70% between 2000 and 2018, largely thanks to the introduction of particle filter regulations in diesel engines.

With more than 20,000 retrofitted vehicles and machines, Switzerland has carried out pioneering work to reduce emissions of diesel soot and black carbon. Swiss environmental legislation requires emissions of carcinogenic substances to be minimized. To protect the population, the Federal Council initiated an action plan in 2006, introducing various measures aimed primarily at reducing the high level of emissions from diesel engines. In 2018, new abatement measures were introduced in the revised Ordinance on Air Pollution Control to address stationary sources and reduce short-lived climate pollutants, such as particulate matter and black carbon from small wood-heating installations and construction machinery. Switzerland has a 2050 climate target of zero net emissions.[57]

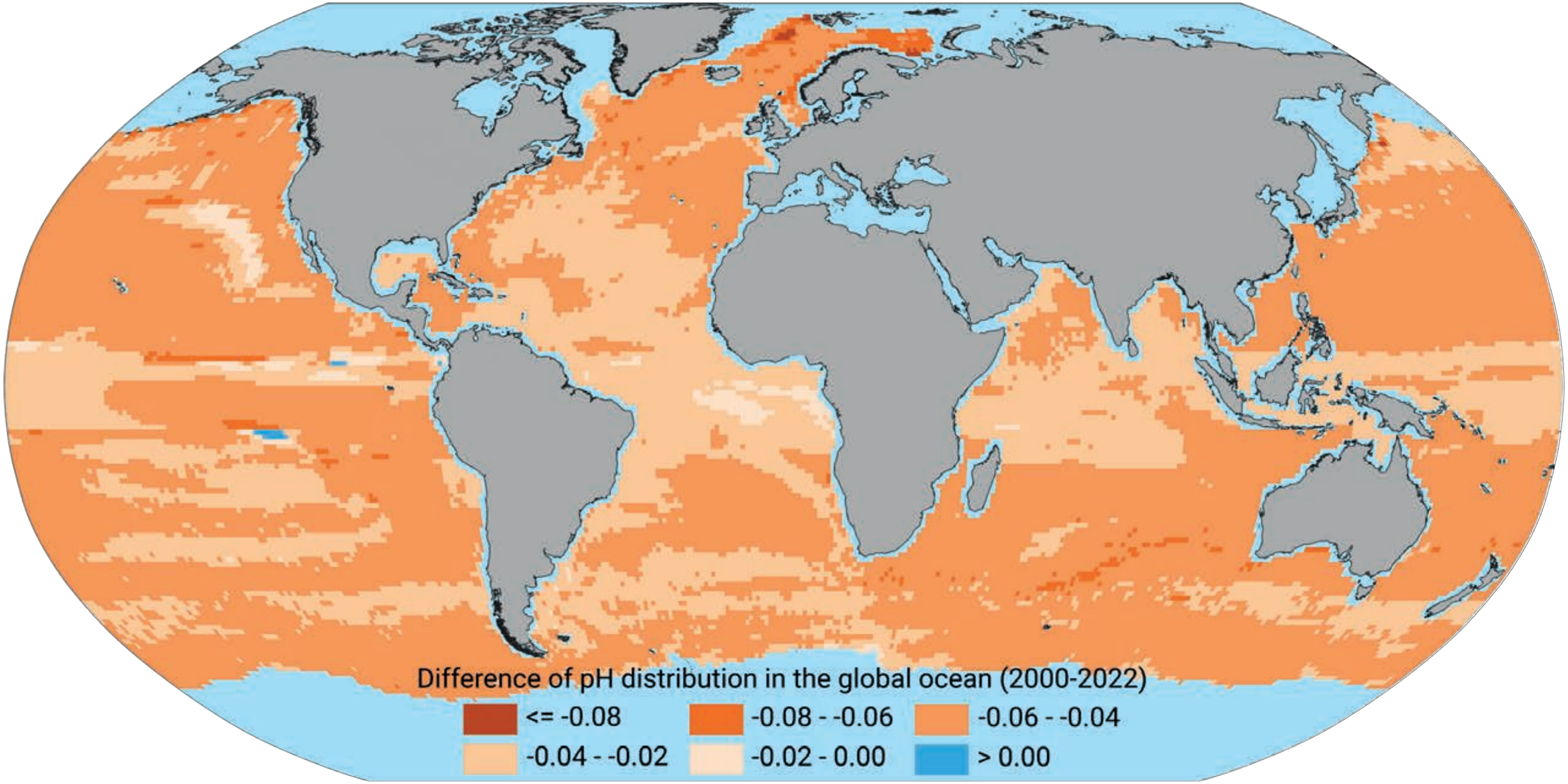
Swiss town

Credit: Zicarlo van Aalderen

Protecting oceans, fishing and food security

Map 18 highlights the global trend in ocean acidification and compares it with the planetary boundary for ocean health, an internationally recognized threshold beyond which the risk of large-scale, potentially irreversible damage to marine ecosystems significantly increases.[58] Ocean acidification occurs as the oceans absorb increasing amounts of carbon dioxide from the atmosphere, leading to a decrease in pH and a reduction in carbonate ions, which are crucial for marine life, especially organisms with calcareous shells like corals and molluscs.[59] As native fish stocks are adapted to thrive within a relatively narrow pH band, stocks are depleted or forced to relocate if water becomes too acidic.

Map 18. **Ocean Acidification: Changes in pH distribution in global oceans, 2000- 2022**



Source: Data: Japan Meteorological Agency, 2023. Cartography: UNEP/GRID-Geneva, 2024

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

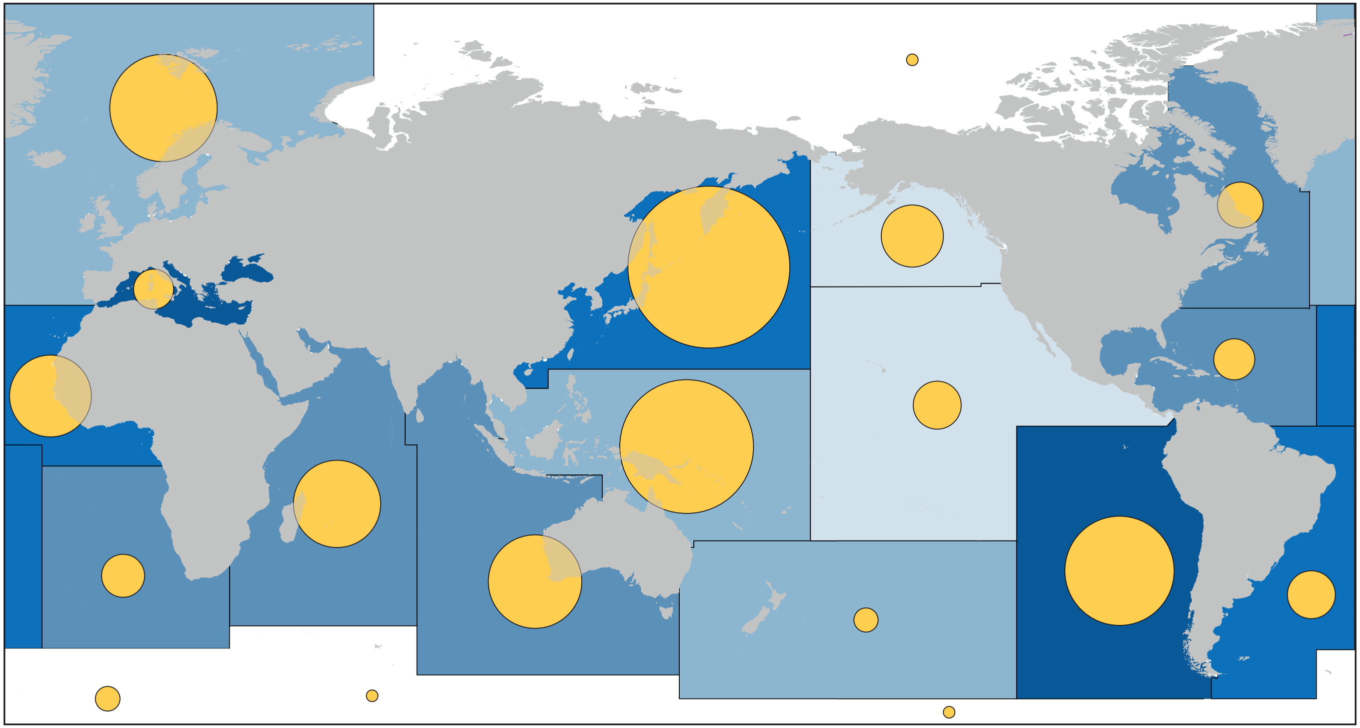
The planetary boundary for aragonite saturation is set to ensure that ocean chemistry remains within a safe range for these species. Exceeding this boundary poses significant risks to marine ecosystems, food security and economies reliant on marine resources, particularly when fish stocks have already been depleted by overfishing.[60]

Map 19 highlights the global issue of overfishing and its significant impacts on food supply and financial stability. Overfishing depletes fish stocks, threatening food security, particularly in communities that rely heavily on fishing for sustenance and income. Commercial tuna fisheries alone contribute more than $40 billion to the global economy annually. However, overfishing has caused the populations of several key species to fall below sustainable levels, endangering marine ecosystems and the industries and communities that depend on healthy stocks for food and livelihoods.

The social and economic consequences are severe, as the collapse of fish populations leads to financial losses in the fishing industry, reduced income for fishers, and higher consumer prices.[61] Moreover, overfishing exacerbates the vulnerability of marine ecosystems to climate change, further destabilizing the fishing industry.[62]

Fisheries are also essential to the wellbeing of rural and coastal communities worldwide, providing an important livelihood and possessing significant cultural value.[63] Of the approximately 60 million individuals involved, around 40% are women.[64] In some coastal countries, such as Senegal, where one in five people work in the fishing industry, the sea is a vital and accessible resource for communities that depend on it for food and livelihoods. With fish catches declining by a staggering 75% in a decade because of overfishing, associated incomes have also fallen by an estimated 40%. This undermines not just food security, but also the ability to purchase necessities for families.[65]

Map 19. **Global fish capture (2020) and fish stock sustainability (2019)**



Fish stocks within biologically unsustainable levels by marine area in percent in 2019

No data | < 20% | > 20% | > 30% | > 40% | > 60%

Fishes capture in 2020, in tonnes x 1000

19 449
10 000
5 000
1 000
500
< 100

Source: Data: FAO, 2022. Cartography: UNEP/GRID-Geneva, 2024

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Action to reduce this risk can be effective, and sustainable fisheries management can help reverse these trends, ensuring the long-term viability of fish stocks and protecting the economic wellbeing of affected sectors. Resilience is achievable with the right policies in place. For example, in Brazil, social protection measures offer a compelling example of how fisheries management can be aligned with livelihood protection for small-scale fishers (Box 18).

Box 18. Unemployment insurance as a resilience-building tool in Brazil

In Brazil, social protection programmes such as unemployment benefits ensure that fishers receive wage compensation when fishing is limited, thus protecting their livelihoods. One such scheme aims to support small-scale fishers affected by the closed season by providing financial compensation equal to the minimum wage during the months when fishing is prohibited. The Unemployment Insurance for Small-scale Fishers programme, or "Seguro-Defeso", is related to one of the fisheries management measures in Brazil, namely the closed fishing season or "Defeso", which seeks to ensure the conservation of exploited stocks and the sustainability of fishing by restricting the permitted fishing period for certain species

An evaluation concludes that the greater the exposure to the programme's benefits, the higher the percentage of children enrolled in school and the lower the percentage of youth out of school or out of work. The results also indicate that the programme avoids the need to seek alternative employment for adult family members. With regard to housing quality, the effects found tend to be medium-term and are more prominent in the components related to improvements in housing floor and sanitary conditions.[66]

Source: FAO (2023)

Salvador, Bahia, Brazil - December 18, 2020: Fishermen are seen during fishing with a trawl along the fishing colony on Pituba beach, in the city of Salvador

Credit: Shutterstock, Joa Souza

This chapter has highlighted how climate change, biodiversity loss, land degradation, pollution and unsustainable development practices combine to push natural systems toward potentially rapid and irreversible change. These so-called tipping points—critical thresholds beyond which ecosystems may collapse or transform dramatically—are drawing closer. Already, environmental shifts are disrupting every part of the natural world, from the air we breathe to our oceans, freshwater, land and soils.

These pressures are expected to intensify as climate change accelerates. Under current policies and even with full implementation of nationally determined contributions to the Paris Agreement, an overall increase in global temperature of 2.6–3.1°C by 2100 is projected.[67]

However, many potential future disasters are not inevitable. Investing to build resilience to hazards now can achieve a positive triple impact: reducing disaster impacts, advancing sustainable development and contributing to global net-zero action. Choices made today will determine whether risk accumulates unchecked or resilience becomes a deliberate outcome of planning and investment. Chapter 4 explores another critical dimension, the economic argument, the growing direct and indirect costs of disasters and the urgent need for improved resilience strategies.

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[1] Introduction by UNEP

[2] CDRI, 2023

[3] Ledesma, 2022

[4] UNESCO, 2024

[5] Wesely, 2021

[6] Wesely, 2019

[7] Alcaldia de Manizales - Gestión del Riesgo, n.d.

[8] Marulanda et al., 2014

[9] Marulanda Fraume et al., 2012

[10] Sarmiento, 2025

[11] WMO, 2023

[12] WMO, 2021

[13] Prentice et al., 2024

[14] GEM Report UNESCO, 2024

[15] WMO, 2021

[16] UNICEF, 2021

[17] The CCRI looks both at (1) exposure to climate and environmental hazards, shocks and stresses, and (2) child vulnerability (UNICEF, 2021).

[18] Carr et al., 2024

[19] Dixit & Ratan, 2025

[20] FAO, 2021

[21] Rojas, 2020

[22] Antipatory action means acting ahead of a predicted hazardous event to prevent or reduce impacts on lives, livelihoods and humanitarian needs before they fully unfold. For more information on AA see: UNDRR & OCHA, 2024

[23] Garay, 2025

[24] Scharping, 2024

[25] Nkonya et al., 2016

[26] Sartori et al., 2019

[27] Nkonya et al., 2016

[28] Bardgett, 2016

[29] WHO, 2024a

[30] Flouris et al., 2024

[31] Teofilovska et al., 2025

[32] IPBES, 2019

[33] Tomalka et al., 2024

[34] UNEP & ISWA, 2024

[35] UNU definition of risk tipping point

[36]Eberle et al., 2023

[37]Mena Benavides et al., 2023

[38]Kundzewicz & Döll, 2009

[39]Richey et al., 2015

[40]United Nations University, 2023

[41]O'Connor et al., 2023

[42]Hutley et al., 2022

[43]Leite-Filho et al., 2021

[44]WBG & ADB, 2021

[45]European Commission, Joint Research Centre (JRC), 2023

[46]Ullah & Khan, 2025

[47]MacCarthy et al., 2024

[48]MacCarthy et al., 2024

[49]Tymstra, 2015

[50]Fournier, 2001

[51]WMO, 2024

[52]WMO, 2024

[53]WHO, n.d.

[54]WHO, 2024b

[55]WHO, 2016

[56]WHO, 2016

[57]CCAC, 2013

[58]The current safe operating limit is set at 2.75 aragonite saturation and is based on pre-industrial levels of 3.44. Aragonite saturation is a way of measuring how well marine creatures will be able to form calcium carbonate structures. If it falls to 1, they can't form them at all, and anything below 2.75 seriously affects their ability to grow and thrive. We're currently at 2.9. (Williams, 2013).

[59]Gattuso & Hansson, 2011

[60]Helmholtz CLIMATE, 2022

[61]Aligica et al., 2017

[62]Cerutti-Pereyra et al., 2024

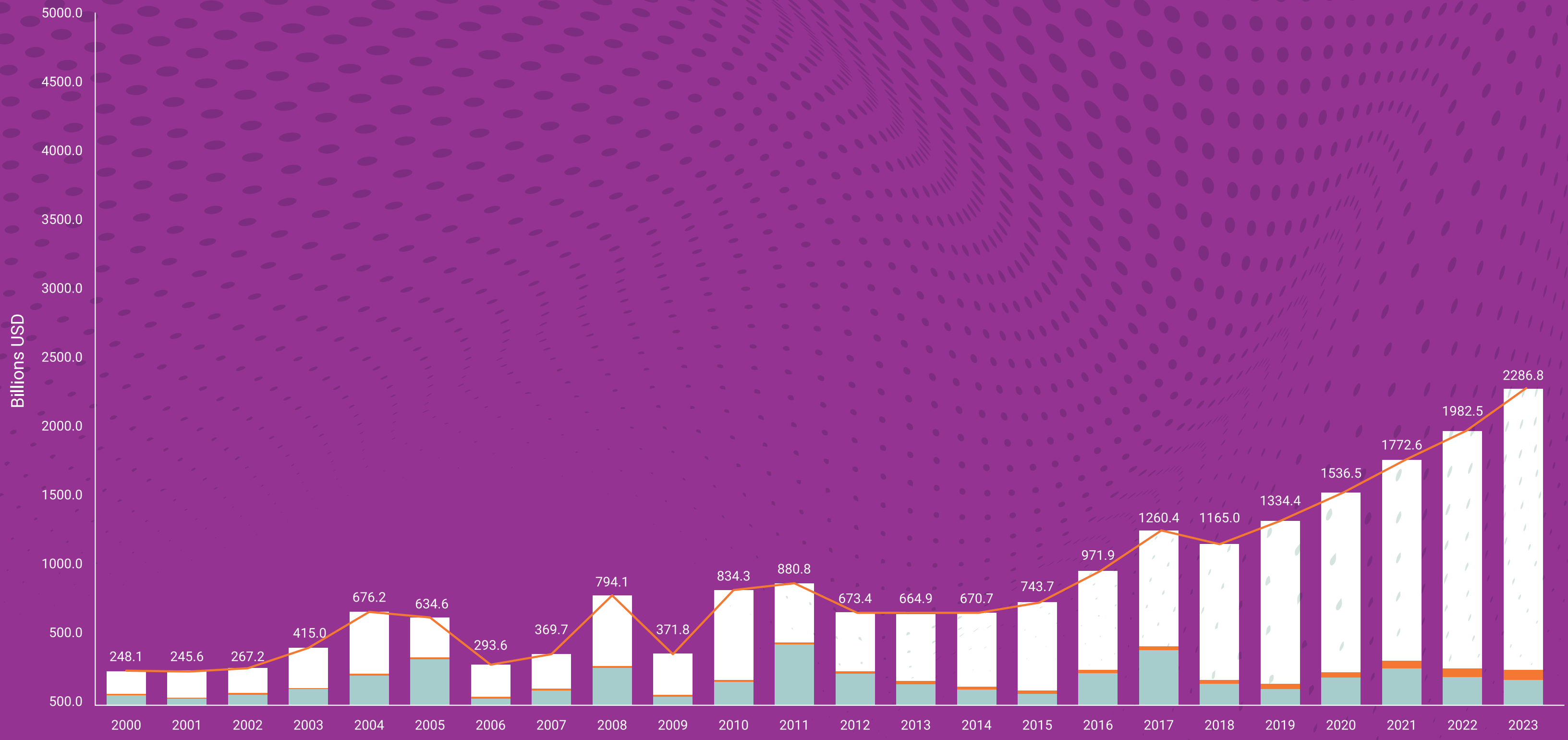
[63]FAO, 2018

[64]FAO, 2023a

[65]Kitz, 2024

[66]FAO, 2022

[67]UNEP et al., 2024



5000.0
4500.0
4000.0
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3000.0
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2000.0
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Billions USD
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245.6
267.2
415.0
676.2
634.6
293.6
369.7
794.1
371.8
834.3
880.8
673.4
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CHAPTER 4

What disasters really cost and why building resilience is worth it

Disaster risk reduction delivers more than just safety. It protects prosperity. Yet while the benefits of investing in resilience are clear, such investments are still far from sufficient. Year after year, disasters take a mounting toll, not just on lives, but on the foundations of economic stability. The losses now extend far beyond the direct costs reported in disaster databases. They are rippling through supply chains, undermining government balance sheets, displacing communities and quietly eroding development gains.

This chapter sets out to answer a deceptively simple question: What do disasters really cost in economic terms?

The answer begins with what is known: between 1970 and 2023, over $6.8 trillion in direct losses were recorded across more than 24,000 disasters. Floods, storms, droughts, extreme heat and earthquakes accounted for the overwhelming majority of these costs and the greatest number of deaths and displaced people. But even these towering figures are only the tip of the iceberg.

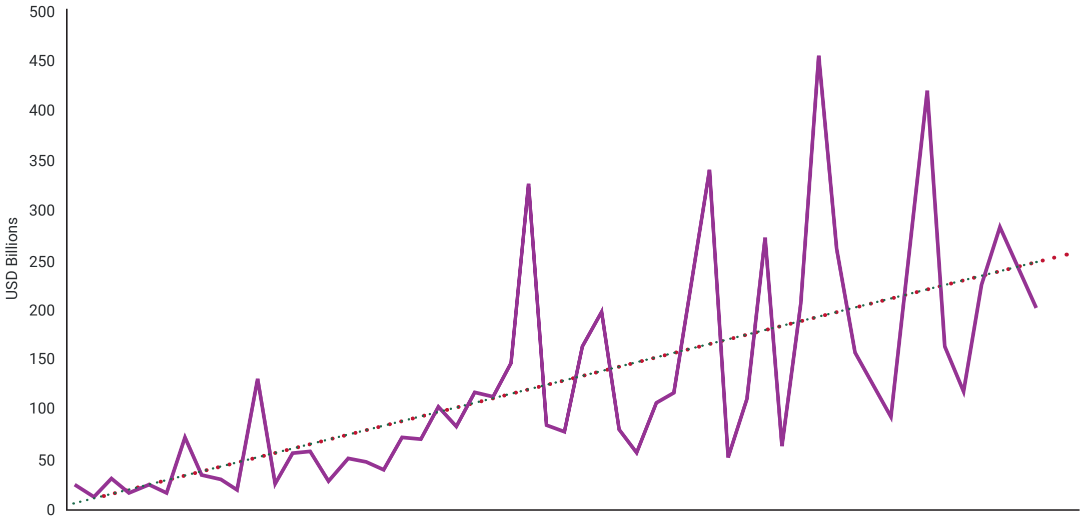
The real cost is far higher.

When losses to health, education, livelihoods, ecosystems and supply chains are factored in, the global bill becomes staggering, closer to $2.3 trillion each year in total disaster related costs. That is nearly ten times the annual direct losses reported in official figures. While these numbers are estimates, the risks they represent are real. For comparison, a national debt of just $300 billion was enough to trigger the European sovereign debt crisis. Disaster risk is increasingly a systemic threat to financial stability on a global scale.

The chapter explores these "missing millions", the vast and under-reported losses that until recently remained invisible. These include migration costs, the loss of informal sector income, long-term health and educational attainment declines, or the cascading effects of infrastructure outages, such as electricity blackouts from tropical cyclones that can affect up to 80 million people in a single event.

The global cost of disasters is growing, and the economic burden of disasters is intensifying. While the direct costs of disasters averaged $70–80 billion a year between 1970 and 2000, between 2001 and 2020, these annual costs grew significantly to $180–200 billion.[1] (Figure 2)

Figure 2. **Rising direct costs of recorded disasters 1970 – 2023**



Source: UNDRR using data from EM-DAR, CRED / UCLouvain, 2025, Brussels, Belgium. Extracted 3 March 2025.

Crucially, these impacts are not distributed equally. Small, developing countries may suffer lower absolute losses, but those losses often represent a devastating share of gross domestic product (GDP). Storms that cost 0.2% of GDP in North America might wipe out 46% of GDP in a Pacific island nation. While affluent households often have buffers, poorer communities face catastrophic outcomes from even modest shocks, with asset losses triggering years of hardship. These "wellbeing losses" are a key focus of emerging resilience metrics, which show how deeply disasters can undermine living standards, especially in highly unequal societies.

Furthermore, disaster impacts do not stop at national borders. Nature loss, mass displacement, disrupted food systems and financial contagion are all part of a more interconnected, systemic risk picture. This, too, creates opportunity. As understanding grows, so does the ability to act.

Indeed, this chapter concludes not with a warning but with a call to action. As countries begin to measure the full extent of their exposure, not just in buildings and roads, but also in ecosystems, health systems, and household wellbeing, the economic rationale for investing in disaster resilience becomes unassailable. Resilience is not just a moral imperative. It is one of the smartest investments a country can make.

Tools like probabilistic risk models can help to estimate future losses better and plan for them. So the second part of the chapter looks at how forward-looking tools like Average Annual Loss (AAL) and probable maximal loss (PML) metrics smooth out short-term volatility and can help capture the impact of low-probability, high-impact events like major earthquakes. By offering an annualized view of expected losses, AAL equips governments, insurers and communities with a tool to help make informed decisions about where and how to invest in risk reduction. Current AAL calculations for three hazards, floods, tropical cyclones and earthquakes, put losses to critical infrastructure alone at over $250 billion a year, with particularly high exposure in Asia and the Americas. Innovations and tools like machine learning and artificial intelligence are speeding up the extension of such methodologies to other hazards, sectors and compound disasters to aid better scenario planning and decision making.

Five hazards drive over 95% of economic losses

Between 1970 and 2023, the economic cost of geophysical disasters like earthquakes accounted for an estimated $1.59 trillion.[2] The direct impacts of some 24,433 reports of floods, storms, droughts and extreme heat worldwide led to more than $5.18 trillion in economic losses, while other disasters totalled an additional $0.10 trillion.[3] Although floods were the most frequent weather-related disaster, storms resulted in the highest human and economic losses. Three of the ten most costly climate-related disasters in the past 50 years were hurricanes: Hurricanes Harvey ($96.9 billion), Maria ($69.4 billion) and Irma ($58.2 billion), all occurring in 2017. These three hurricanes alone accounted for 35% of the total economic losses from the top 10 global disasters from 1970 to 2019.[4]

As outlined in Chapter 2, hazards like floods and earthquakes can also trigger compound disasters, such as landslides in mountainous areas, which have associated average annual economic losses estimated to be $26 billion globally.[5]

Droughts also constituted a major economic burden. Based on historical data, recent estimates suggest that their impacts cost approximately $307 billion annually.[6] These losses, as estimated by the United Nations Convention to Combat Desertification (UNCCD), are not confined to direct damage in affected sectors but also encompass indirect, long-term costs that ripple through the economy, such as loss of livelihoods and land degradation.

The costs of extreme heat are also increasing. Between 2000 and 2023, extreme temperature events caused economic damages close to $73 billion.[7] The most notable peaks were in 2003 and 2008, when total costs of $20.7 billion and $31 billion were recorded. In 2021, extreme heat led to $6.3 billion in damages in North America alone.[8]

However, as outlined in the previous chapter, additional hazards such as wildfires are becoming more costly globally. For example, until recently, the most expensive disaster ever recorded was the 2011 Tohoku earthquake and tsunami in Japan. It destroyed more than 123,000 houses and damaged almost one million more (98% of the damage was attributed to the tsunami). The resulting costs were estimated at $220 billion.[9] Preliminary estimates of the wildfires that hit Southern California in January 2025 indicate that the costs of this event may be even higher, at more than $250 billion, partly because of the high asset values in the areas impacted.[10]

"The missing millions": What direct disaster cost estimates leave out

Looking only at the 'big five' hazards (earthquakes, floods, storms, drought and extreme heat) does not capture the scale of disaster-related losses. In 2023, those five hazards accounted for direct economic costs of over $195.7 billion, or approximately 0.15% of global GDP.[11] However, much of what is lost during and after a disaster, in livelihoods disrupted, degraded ecosystems or lives derailed by displacement or long-term health impacts, is not counted.

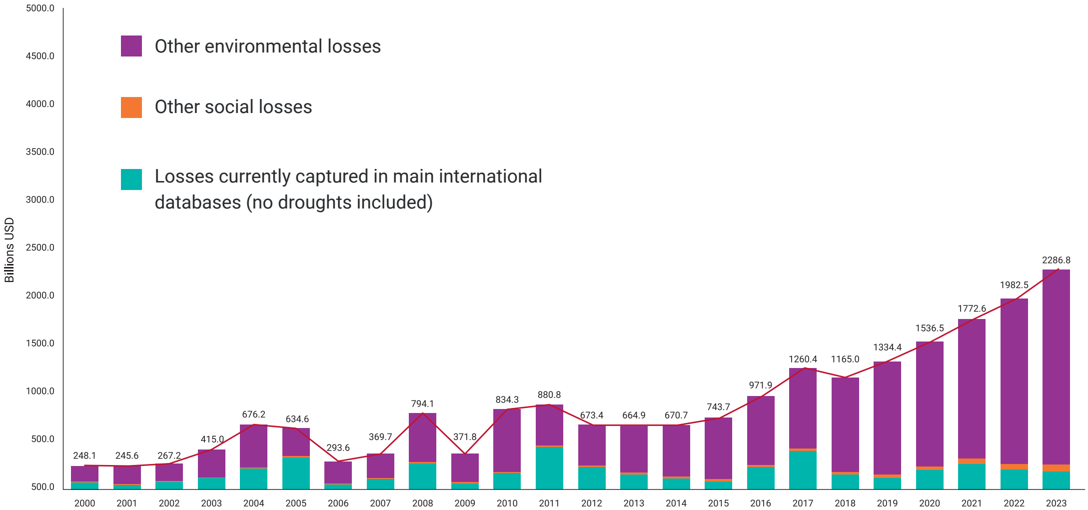
Once cascading costs are considered, the estimated indirect economic impact of disasters in 2023 climbs to roughly $2.3 trillion or 2% of global GDP. While these figures remain estimates, the key message is that disasters can have outsized and multiplying impacts on economies, so policy choices and investment patterns to reduce the risk of hazard impacts (including climate change) matter.

For example, the indirect impacts of extreme heat not only disrupt everyday life but also lead to long-term economic and social costs.[12] Extreme heat events in Europe contributed an extra $2.8 billion in annual losses due to increased hospital admissions and diminished labour productivity.[13] Extreme heat increases energy demand, reduces work productivity and strains healthcare systems due to a rise in heat-related illnesses.[14] In urban areas, extreme heat events cause maintenance and repair costs to surge by 12–15%, resulting in an extra cost burden of about $4.5 billion annually in major cities, posing significant challenges for sustainable urban planning.[15] Zooming in on the agriculture sector, the past 30 years have seen an estimated loss of $3.8 trillion in crops and livestock production due to disaster events, translating to an average annual loss of $123 billion per year, or 5% of global agricultural GDP.[16]

Understanding the scale of the unreported losses

The charts below give a sense of the scale of these differences. In Figure 26a, the lowest tier shows the direct economic losses from disasters.[17] The subsequent bars show additional losses as accounted for across other sectors and ecosystems, including many of the wide-ranging social and planetary impacts discussed earlier in this report. These include, for example, the costs of human displacement, ecosystem losses, estimated sea level risk and other disaster and climate change related costs as reported by various United Nations entities, but which are not currently captured in disaster risk reduction reporting.[18] Figure 26b illustrates the approximate composition of these additional losses.

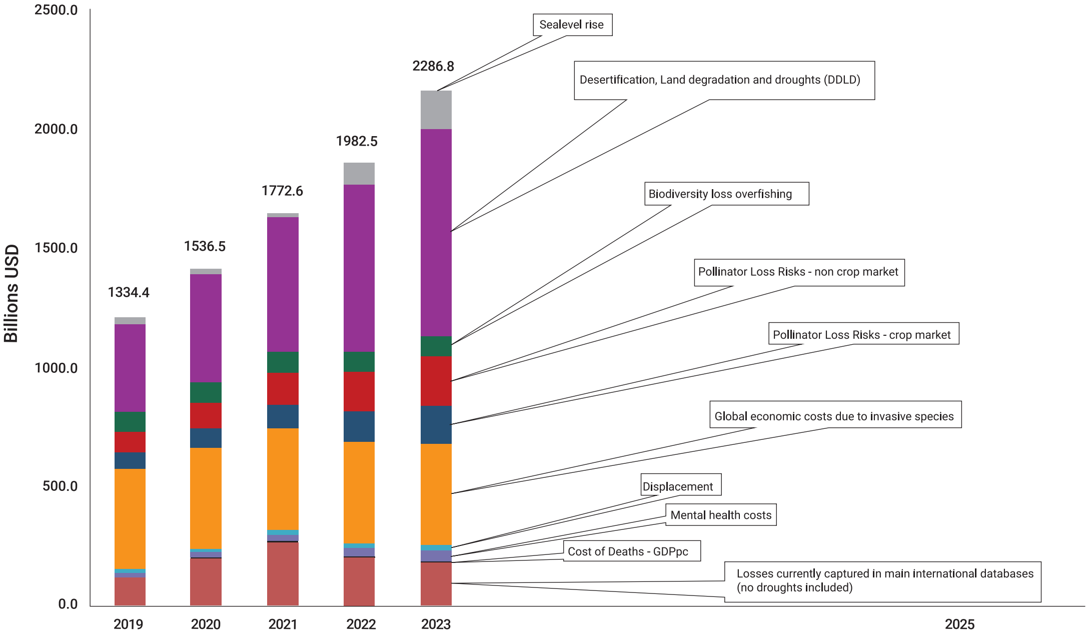
Figure 26a. **The costs of disasters: official, social and environmental, 2000-2023**



Source: UNDRR using data from CRED / UCLouvain, 2025; Desinventar, 2025; World Bank, 2025; WHO, 2024a; WHO2024b; IDMC, 2025; IPBES, 2024, FAO, 2023; IPBES, 2016; World Bank, 2016; UNCDD, 2024; UNEP, 2014

Strikingly, when these are factored in, the graph shows not only significantly higher costs every year but also a more pronounced increase in annual costs between 2000 and 2023. While the annual reported losses (shaded red in the graph) fluctuate significantly, to the point that it is difficult to point to a consistent trend through the period, the total cost when indirect losses are factored in is almost 10 times higher in 2023 ($2,286.8 billion) than in 2000 ($248.1 billion) – a steep upward incline that is generally reflected in the period as a whole, notwithstanding some variance from year to year.

Figure 26b. Historic cost of disasters as reported and with additional indirect impacts factored in (1970 – 2023)



Source: UNDRR using CRED and UCLouvain, 2025. Extracted 22 January 2025; Desinventar, 2025. Extracted 26 February 2025; World Bank, 2025. Extracted 22 January 2025; WHO, 2024; IDMC, 2024; Roy et al., 2024; FAO, 2023; Nkonya, Mirzabaev, and Von Braun, 2016; UNCCD, 2024; Aze, Barry, and Bellerby, 2014.

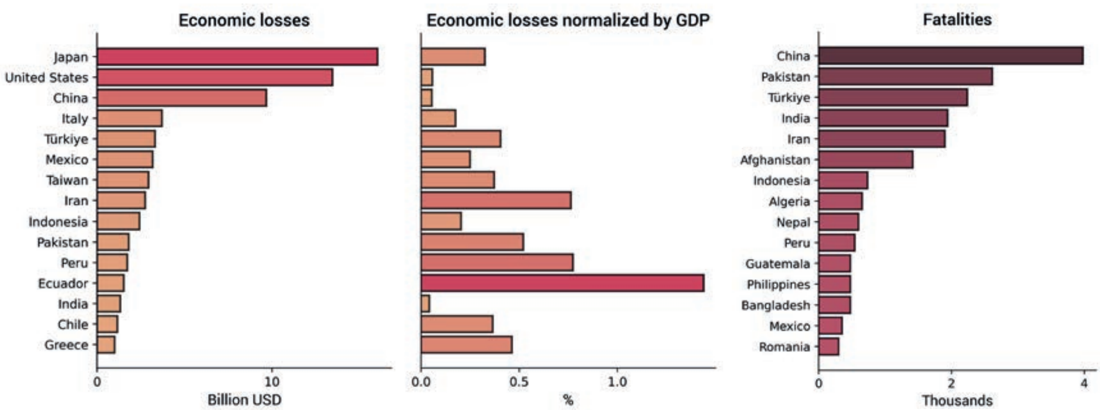
Note: The losses from the main international datasets in this chart are derived from EM-DAT and Sustainable Framework Monitoring System data. Other cascading losses are included according to the extended methodology referenced in the supporting documentation (Annex I).

Understanding disaster risk is not just about adding up global losses. It's also about recognizing how unequally those losses are felt across countries and regions.

Economic costs and development impact

As outlined in Chapter 2, economic losses are not always aligned with human costs. For instance, the chart below looks at the average annual costs of earthquakes. The bar chart on the right of Figure 27 shows the total fatalities, while the two graphics on the left look at the highest economic costs in billions of dollars and percentage of GDP, respectively.

Figure 27. **Economic cost of earthquakes, by selected countries (based on Average Annual Loss calculations)**



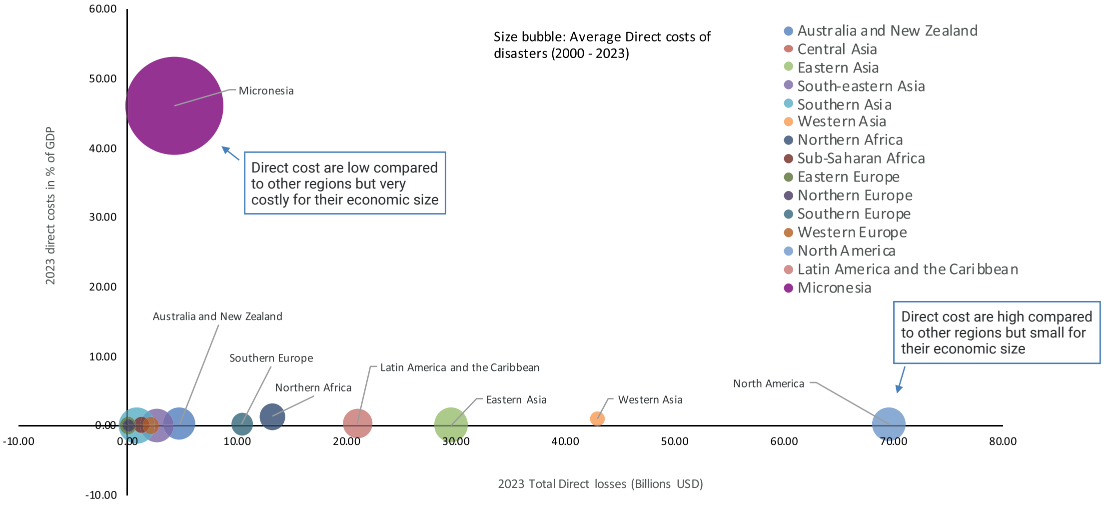
Source: GEM Foundation, 2024

Large countries with sizeable economies better absorb localized shocks from an earthquake, while smaller countries may be disproportionately affected by moderate impacts. For example, on average, Japan, the United States of America and China can expect to see in excess of $10 billion in annual economic losses from earthquakes. Nevertheless, the highest net losses in absolute terms are not the same as economic losses as a percentage of GDP. For example, while Ecuador does not feature in the top five in terms of total economic losses to earthquakes, it ranks the highest in how much those losses constitute as a percentage of GDP (approximately 1.4%). The scale of economic losses is also quite different than the scale of fatalities. Many countries that incur major economic losses have at least been able to reduce deaths and life-years lost due to a major event.

Large, geographically diversified countries can better absorb localized shocks partly because the impacts are often confined to a specific area, leaving the broader economy relatively intact. In contrast, smaller countries, with less geographic diversification, may be disproportionately affected by even moderate absolute losses.

As Figure 28 shows, these disparities also play out when looking across total disaster risk across regions. For example, in 2023, North America had by far the most significant economic exposure to disasters overall, with $69.57 billion in direct losses. These nevertheless represent a relatively modest share (0.23%) of subregional GDP. Micronesia, on the other hand, incurred only a fraction of these net losses, $4.3 billion, but with a far greater relative impact (46.1%) on its subregional GDP.

Figure 28. The total (in $billions) and relative (% of GDP) cost of disasters by subregion, 2023



Source: UNDRR using CRED and UCLouvain, 2025

Figure 29. Absolute and relative direct costs of disasters by subregion annually, 2005, 2023, as a percentage of GDP and on average 2000-2023

Subregions	2005		2023		Average 2000 - 2023	
	Total Direct losses (Billions USD)	% of Subregion's GDP	Total Direct losses (Billions USD)	% of Subregion's GDP	Avg Direct losses (Billions USD)	Avg % of Subregion's GDP
Australia and New Zealand	0.35	0.043	4.70	0.237	4.86	0.363
Micronesia*	0.002	0.028	4.30	46.139	0.30	3.374
Central Asia**	0.09	0.112	0.01	0.003	0.10	0.074
Eastern Asia	21.36	0.259	29.56	0.122	55.12	0.417
South-eastern Asia	1.43	0.153	2.66	0.070	7.25	0.377
Southern Asia	19.59	1.506	0.78	0.016	10.57	0.450
Western Asia	0.00	0.000	42.93	1.008	2.65	0.083
Northern Africa	0.60	0.160	13.20	1.335	1.18	0.238
Sub-Saharan Africa	0.04	0.005	1.20	0.062	1.25	0.090
Eastern Europe	2.89	0.177	0.05	0.001	1.75	0.099
Northern Europe	8.45	0.211	0.08	0.001	2.15	0.057
Southern Europe	7.94	0.220	10.42	0.218	5.80	0.166
Western Europe	5.77	0.083	2.14	0.020	7.58	0.098
Northern America	248.19	1.746	69.57	0.233	72.61	0.388
Latin America and the Caribbean	21.60	0.747	21.00	0.294	15.24	0.312

Source: UNDRR using CRED and UCLouvain, 2025; World Bank, 2025

Note: *Figures for 2005 correspond to 2004. **Figures for 2023 correspond to 2021

The impact of a disaster on a country's economy also depends on its policies, investments and development levels. Disaster-related losses can fluctuate significantly from year to year, depending on conditions. In the case of North America, for instance, while the annual cost of disasters as a proportion of GDP was 0.23% in 2023, in 2005 the proportion was almost seven times higher at 1.74% as storms like Hurricane Katrina exposed vulnerable cities like New Orleans to significant losses that year.[19] However, because many of these losses were covered by insurance, the risk was shared across the public and private sectors. In contrast, in small island developing states such as Micronesia, where the cost of disasters as a share of national GDP was 0.03% in 2006 and a massive 46% in 2023, risk transfer mechanisms that can share losses across the public and private sectors were much less prevalent.[20] As a result, the national economy was much more acutely affected.

While on average, disaster impacts are likely to be more acute in low-income countries, wealthier countries are by no means immune. For instance, as described in Box 19, flooding has had a serious economic impact in the Italian province of Emilia-Romagna, despite being one of the most prosperous regions in the country.

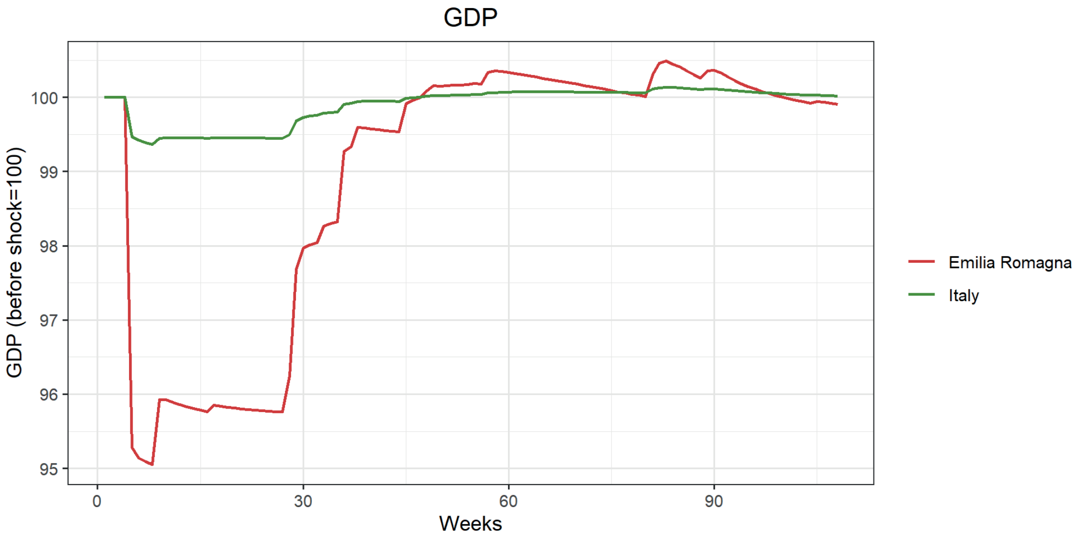
Box 19. Assessing the economic impact of local floods in Emilia-Romagna on Italy's national GDP

In May 2023, the Emilia-Romagna region, a vital economic hub in northern Italy, was struck by devastating floods triggered by intense and prolonged rainfall. The floods caused widespread devastation, with 23 rivers overflowing and more than 100 communities severely impacted. Critical infrastructure such as roads, railways and electrical networks was obliterated, while over 400 landslides wreaked havoc. The floods also devastated nearly 20,000 production units, paralyzing one of Italy's most economically significant regions.

To assess the economic impact of the flood, mapping techniques and geo-spatial data were correlated with the local labour market, allowing for a detailed assessment of the share of the labour force affected across various sectors in the region. By examining the evolution of GDP at regional and national levels, the research highlights how localized events can influence macroeconomic trends. As illustrated in Figure 30, the economic losses stemming from the Emilia-Romagna floods had a notable impact on Italy's national GDP.

The trends observed in the national GDP closely mirrored those of the regional GDP, albeit to a lesser extent. The peak decline in Emilia-Romagna's regional GDP was estimated at almost 5%, while the corresponding decrease in Italy's national GDP was approximately 0.6%. This analysis underscores the interconnectedness of regional and national economies, illustrating how shocks in a key region like Emilia-Romagna can reverberate across a country's entire economic landscape.[21]

Figure 30. **Economic impact of the May 2023 flooding in Emilia-Romagna at a regional and national level**

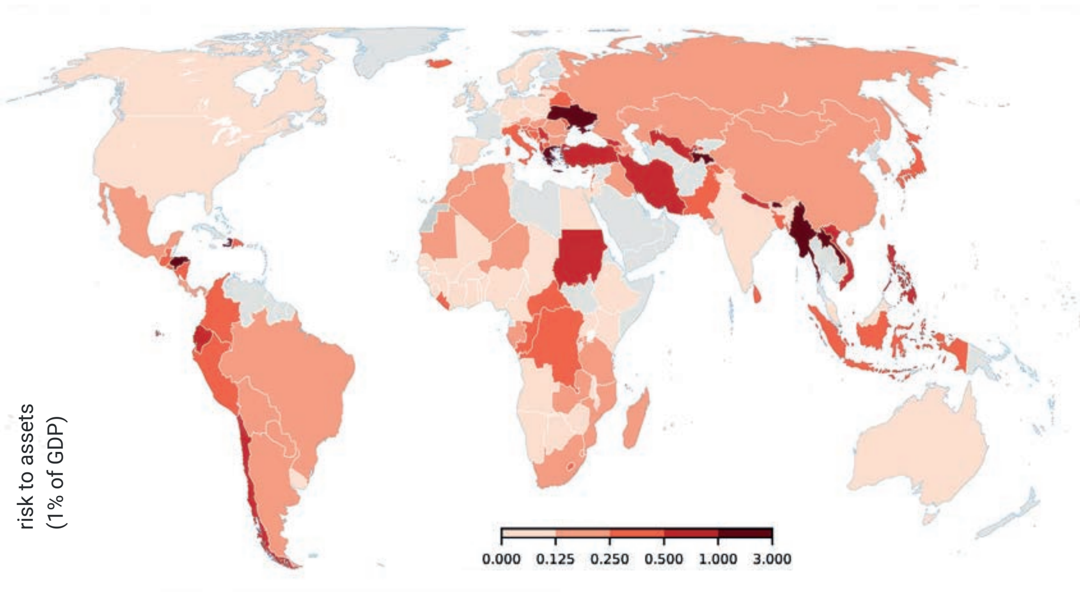


Source: Di Noia et al (2024)

Like the Micronesia example above, an economic loss figure looks very different when considering the total assets in a country. Focusing on asset losses alone tends to place risk hotspots in more affluent areas, as wealthier countries or households tend to own more assets with higher economic values.[22]

However, the picture looks very different when asset losses are expressed as a percentage of GDP, as in this World Bank Analysis of 132 countries mapped below. The total global annual asset losses of the modelled disasters amounted to $314 billion, but assets only tell part of the story.[23] (Map 20)

Map 20. Global asset losses as a percentage of GDP based on modelled loss estimates due to hazards provided by the CDRI Global Resilience Risk Model and Resilience Index (GIRI)



Source: Middelanis, R et al, (2025). "Global socio-economic resilience to natural disasters", World Bank Group.

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Simply put, $1 of asset losses will have a more severe impact on the wellbeing of a poor person than on that of a comparatively wealthy person. Therefore, investment approaches for risk reduction must account for the distribution of losses and the capacity of households to cope with and recover from these losses.

Analysis of the data identifies another important caveat. The World Bank uses the term "wellbeing losses" to capture how consumption is forgone due to disasters, living standards and people's ability to live safe, stable, and fulfilling lives.[24] A country's capacity to minimize wellbeing losses is a form of socio-economic resilience. Given the same asset losses in two countries, one may be more capable of reducing the resulting impacts on wellbeing than the other. Therefore, investment approaches for risk reduction need to account for the distribution of losses and the capacity of households to cope with and recover from these losses.

Map 21 looks across the same 132 countries, mapping this socio-economic resilience as the ratio of asset losses to wellbeing losses. The scale applied suggests that a resilience level of 25% implies that the wellbeing losses are equivalent to reducing national income by four times the value of the destroyed assets.

Bounce back potential: Investing to accelerate recovery times and reduce losses

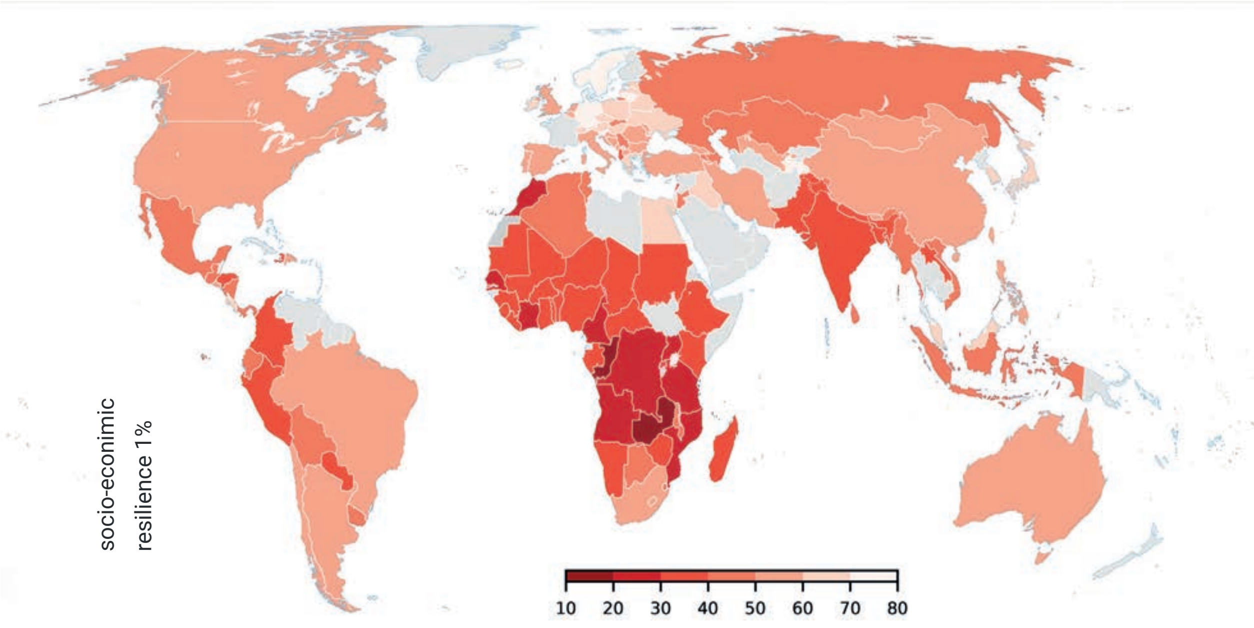
While economic growth appears to increase a country's capacity to minimize wellbeing impacts, total wellbeing impacts are also driven by wealth inequality. In general, the higher a country's level of inequality, the lower its socio-economic resilience.

Precisely because even $1 of asset losses will have a more severe impact on the wellbeing of a poor household than a more affluent one, disaster risk reduction investment strategies must consider how losses are distributed and the capacity of individual households to cope with and recover from them.

In economic terms, a longer recovery time can be seen as an indirect disaster impact that affects households long after the immediate shock. The term "recovery duration" refers to the time a household needs to restore 95% of destroyed asset losses following a hazard and is closely correlated to socio-economic resilience.

Map 22 shows the average household recovery duration within a country, both for a set of individual hazards and across all hazards. It shows that households in low- and lower-middle-income countries take significantly longer to recover from a disaster than their counterparts in higher-income countries in every hazard type. Households in high-income and upper-middle-income countries recover 36% and 27% faster than their counterparts in low-income countries, respectively.

Map 21. **Global map of socio-economic resilience (asset losses divided by wellbeing losses)**



Source: Middelanis, R et al, (2025). "Global socio-economic resilience to natural disasters", World Bank Group.

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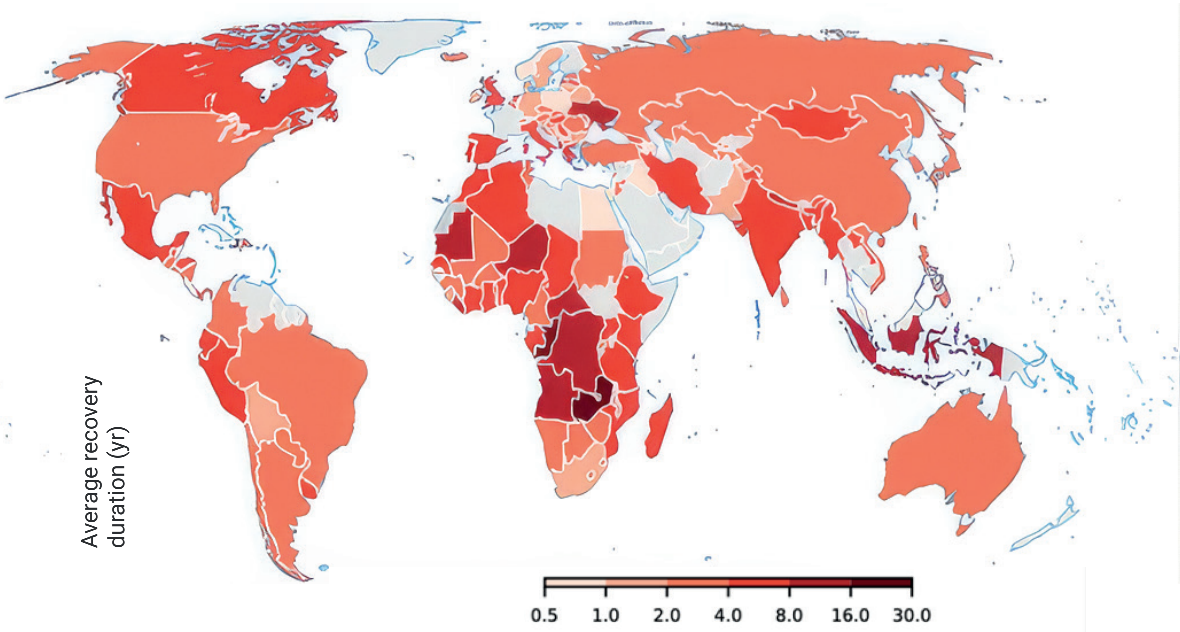
Overall, the map shows significant country-level variations in socio-economic resilience, with those in sub-Saharan Africa and South Asia especially low. When country data is compared, the most significant relative asset losses occurred in Haiti and Tajikistan, where losses accounted for 2.4% of each country's national GDP. Both countries are among the countries with the largest wellbeing losses, though of markedly different magnitudes: in effect, every $1 of asset losses was equivalent to reducing the national income by $1.30 in the case of Tajikistan and $3.62 in the case of Haiti. The metric reveals a sobering truth: disasters have the biggest impacts on wellbeing and development in contexts where resources and resilience are already limited.

The World Bank study estimated that global annual asset losses of the modelled disasters amounted to $314 billion, resulting in $620 billion of wellbeing losses.[25] Effectively, this doubles the loss.

Put differently, every dollar of asset losses avoided through risk reduction would be repaid twice in wellbeing benefits. In addition, this wellbeing benefit would impact the poorest the most. This disparity is a massive opportunity. Focused disaster risk reduction investment is a powerful lever accelerating sustainable development goal achievement, particularly for lower-income contexts.

Map 22. Average post-disaster recovery duration, by country & Figure 23: Median recovery duration by country income group



Source: Middelanis, R et al, (2025). "Global socio-economic resilience to natural disasters", World Bank Group.

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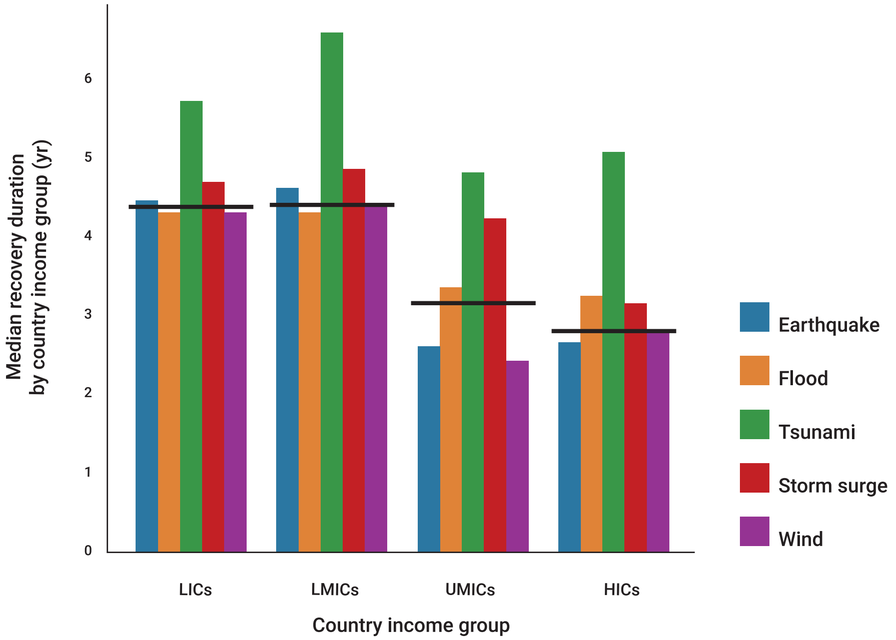


Source: Unbreakable team, 2025

The map shows country-level recovery duration as an average population-weighted recovery duration of affected households across all hazards. The bar chart shows median country-level recovery duration of low-income countries (LICs), lower-middle-income countries (LMICs), upper-middle-income countries (UMICs) and high income countries (HICs) by hazard (bars) and across all hazards (horizontal lines).

As discussed further in Chapter 6, it is possible to design innovative products to help communities avoid asset losses and recover faster. For example, the case study from Nepal below shows how farmers were able to combine investments in early warning and disaster risk reduction with an insurance scheme that protected their assets and accelerated the recovery of poor households in a region with recurrent floods.

Box 20. Strengthening the economic resilience of farming communities in Nepal through the Index-Based Floor Insurance programme

Farmers in vulnerable communities in the Lower Karnali River basin in Nepal frequently faced flood disasters that threatened their livelihoods. On several occasions, due to prolonged inundation, families lost their crops and seeds, household assets and access to critical services. Efforts to manage flood risks have been constrained by inadequate financing mechanisms. While farmers received relief assistance to survive the disaster, they lacked access to existing indemnity insurance to compensate for their losses.

The Flood Resilience Measurement for Communities helped identify innovative mechanisms for risk financing. In collaboration with government authorities, local financial institutions and a private insurance company, the Index-Based Flood Insurance (IBFI) was designed and piloted across communities in the Lower Karnali River Basin. Working with communities to identify local risks and vulnerabilities, the project installed much-needed weather stations and enhanced the capacity of decision-makers and residents to manage early warning systems. Additionally, local financial cooperatives were trained on how to administer the insurance.

The value of this system was soon demonstrated in the wake of another disaster. In 2022, following extreme rainfall, the flood levels in the Karnali River reached a height of 10.8 metres, triggering the first payout (10% of the insured amount), followed by a second payout (25% of the insured amount) when the waters rose to 11.8 metres. The payments were delivered to all enrolled farmers within 22 days, significantly faster than other indemnity insurances, which can take months. The payout provided multiple benefits to farmers, from ensuring their immediate food security and household expenses to enabling livelihood diversification and investment in flood-resilient seeds and crops. The success of the IBFI programme led to an almost five-fold increase in enrolment the following year, along with demands for expanded coverage and replication to tributary rivers and additional communities.

Terraced Farm, Nepal.

Credit: Michael Estigoy

Disaster, debt and credit ratings

Because resilience is low in many developing countries, large-scale disasters can trigger sovereign-rating downgrades when the need for financial assistance is most acute. To gauge financial risk, investors rely on sovereign credit ratings, issued by ratings agencies, that assess a nation's ability to repay its debt. Major disasters can have longer-term impacts, particularly if they depress investor confidence. Besides straining government finances, disaster risk, if not well managed, may discourage investment, reduce economic growth and increase the debt. A country's credit rating determines its borrowing costs, influences investor confidence, and impacts economic stability and growth.

For example, following the 2022 floods that led to over 1,700 deaths and $30 billion in damages in Pakistan, capital markets and the country's sovereign credit rating reflected substantial risk. As climate change makes extreme events in many regions more frequent and intense, future climate-induced rating downgrades may be more likely. Understanding these risks is essential for wider economies and investors because pension funds, central banks, and insurers are all major holders of sovereign debt.[26]

The fiscal landscape in many disaster-affected countries deteriorates as governments shift resources towards responding and recovering from a disaster. This puts pressure on often already stretched national budgets.

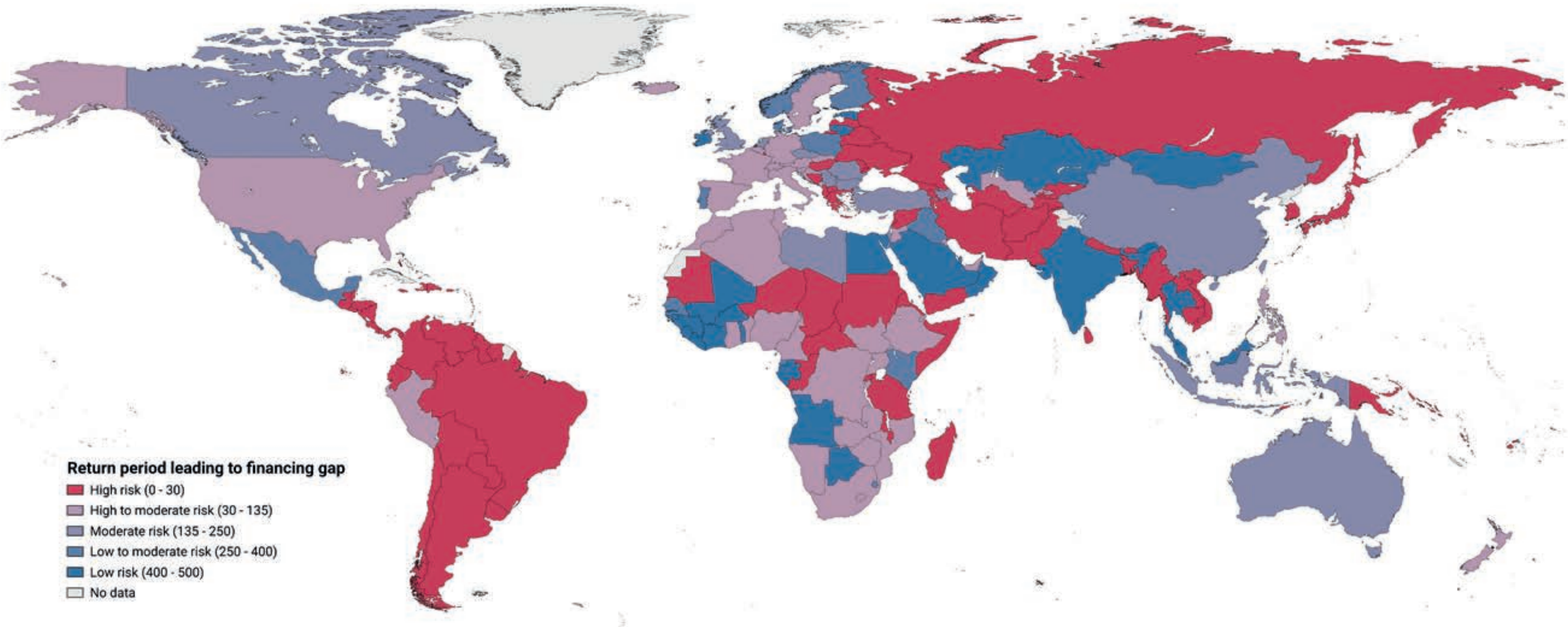
The map below, developed by the International Institute for Applied Systems Analysis (IIASA), shows how often a country may expect a fiscal gap, when a disaster is so costly it can no longer meet its debt obligations, making it more likely to default. Concerningly, for 61 vulnerable countries, the modelling results, which were based on a combination of current hazard and economic indicators, found that fiscal gaps could be expected at least every ten years (an annual probability of 10%). In contrast, in another set of 54 countries across low-income, emerging and advanced economies, such fiscal gaps could be expected only every 50 years (an annual probability of 2%), most likely due to lower hazard vulnerability and exposure.

Averting fiscal crises in poorer countries

The IIASA study further underscores that these economic outcomes are not inevitable. The study shows how having better disaster risk financing options can help stop this bifurcation between countries increasingly caught in a rapid cycle of disaster-related fiscal crises and those more able to develop sustainably. Specifically, the study shows how International Monetary Fund (IMF) Special Drawing Rights (SDR) can soften the impact of disasters.[27] The team modelled a scenario in which low-income and emerging economies were allowed to access 10% of their SDR entitlement in case of a major disaster. Applying this investment vehicle delayed the likelihood of fiscal crises by 19 years for low-income countries and 12 years for emerging economies (a change in annual probability of 5% and 11%, respectively). This investment in risk reduction would have a massive development dividend.

Although estimates, these findings underpin the urgency of explicitly making disaster risk reduction a key principle in financial architecture reform. Special Drawing Rights are not expensive tools for the IMF to deploy, particularly for small economies, and correctly applied, they can have a massive development impact in helping low-income and emerging countries avoid damaging long-term disaster impacts.

Map 23. **Fiscal gap return periods for flooding, windstorm, tsunami and earthquake hazards**



Source: Data: IIASA, 2024;
Cartography: GEM Foundation, 2024

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Policymakers must recognize the importance of risk reduction in their fiscal policies. With more intense and frequent disasters projected in the future, credit agencies, insurance companies and other financial actors are increasingly likely to place a premium on preparedness and risk reduction. Those countries with clear strategies in place may enjoy stronger credit ratings.

As discussed in more detail in Chapter 6, tools exist that can account for a government's efforts to adapt to climate change and wider disaster risks. Increasingly, proactive fiscal planning and proof of resilience investments may help prevent potential sovereign downgrades. This could benefit emerging and developing economies, vulnerable to climate risks and burdened with high debt levels.[28]

Using probabilities to combat volatility

Looking at the past is not enough to prepare for the future. Disaster losses vary wildly from year to year, and that volatility can make it harder to plan. Risk experts are, therefore, turning to tools that look at both the past and the future by simulating thousands of possible scenarios to help governments anticipate impacts before they occur.[29] Probabilistic models help to do this by providing insights into average annual losses (AAL) and probable maximum losses (PML) and looking beyond annual fluctuations to assess the impact of 1-in-100 or even 1-in-1000-year low-probability and high-impact catastrophic events. In short, such tools offer a way to see the financial stakes of future disasters more clearly before the worst happens.

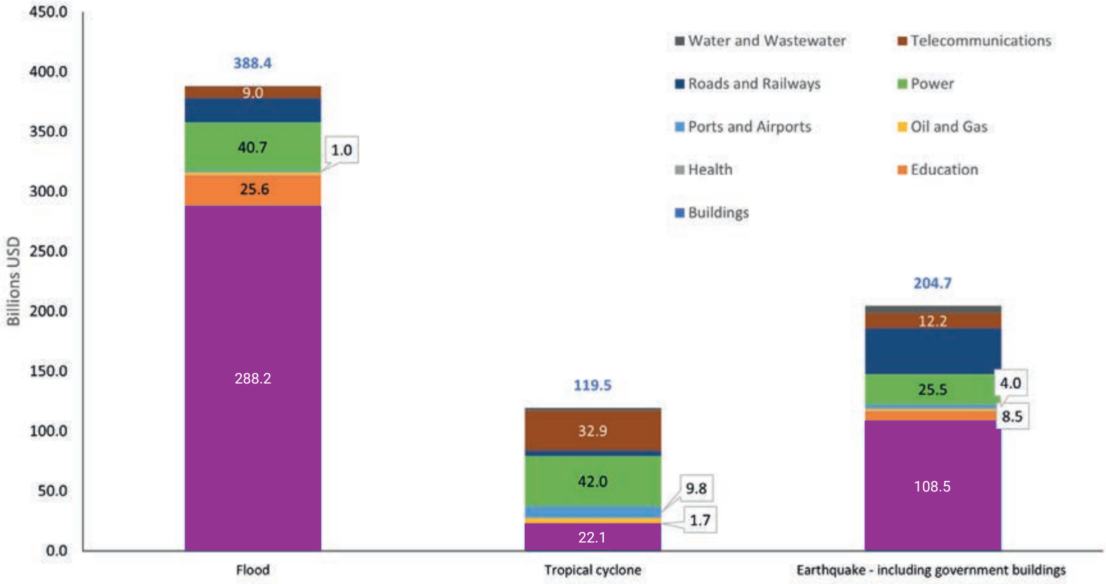
As outlined in more detail below, there are still gaps in the coverage and content in this emerging field. However, All and PML-based analytics can be a powerful tool for policymakers, central banks and investors to understand the human and financial impacts of disasters on societies and economies.

Innovations in areas such as machine learning and artificial intelligence are accelerating the pace of this work to provide policymakers with better tools to manage the social and fiscal risks of disasters. These methods are also being applied to wider sectors such as agriculture, ecosystem service losses and migration costs. They are also being extended to better understand hazards such as wildfires and multi-hazard losses. These exciting developments offer the possibility to expand significantly current knowledge on the true scale and nature of disaster risk, thus facilitating more targeted investment to address these challenges.

Average annual losses and the costliest five hazards

The section below provides a snapshot of available probabilistic analyses for the costliest hazards. For example, Figure 32 summarizes current economic cost AAL calculations of critical infrastructure on three major hazards, floods, tropical cyclones and earthquakes, drawing on open-source information from the Coalition for Disaster Resilient Infrastructure (CDRI).

Figure 32. Annual average losses by sector from floods, earthquakes and tropical cyclones

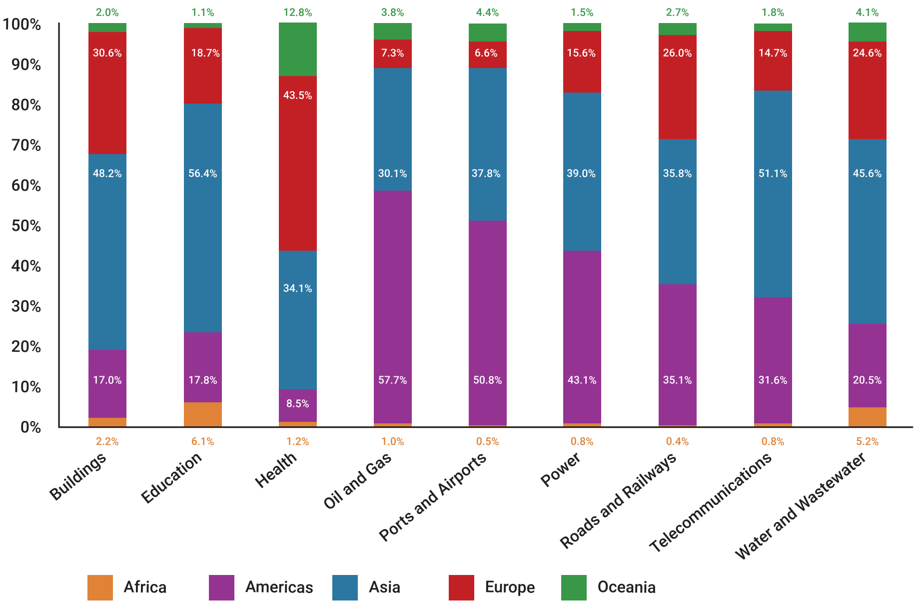


Source: UNDRR using data from CDRI (2023)

The annual average loss for critical infrastructure sectors due to these three hazards globally is $257.2 billion[30]. There are significant regional differences in losses, however, with $2.3 billion of losses in Africa, $103.7 billion in the Americas, $126.9 billion in Asia, $56.7 billion in Europe and $5.9 billion in Oceania.[31] Again, as outlined earlier, lower $losses in Africa do not necessarily mean less of an impact on GDP or sustainable development.

Figure 33 below further illustrates how AAL varies by sector.

Figure 33. Regional and sectoral distribution of AAL from earthquakes, floods and tropical cyclones

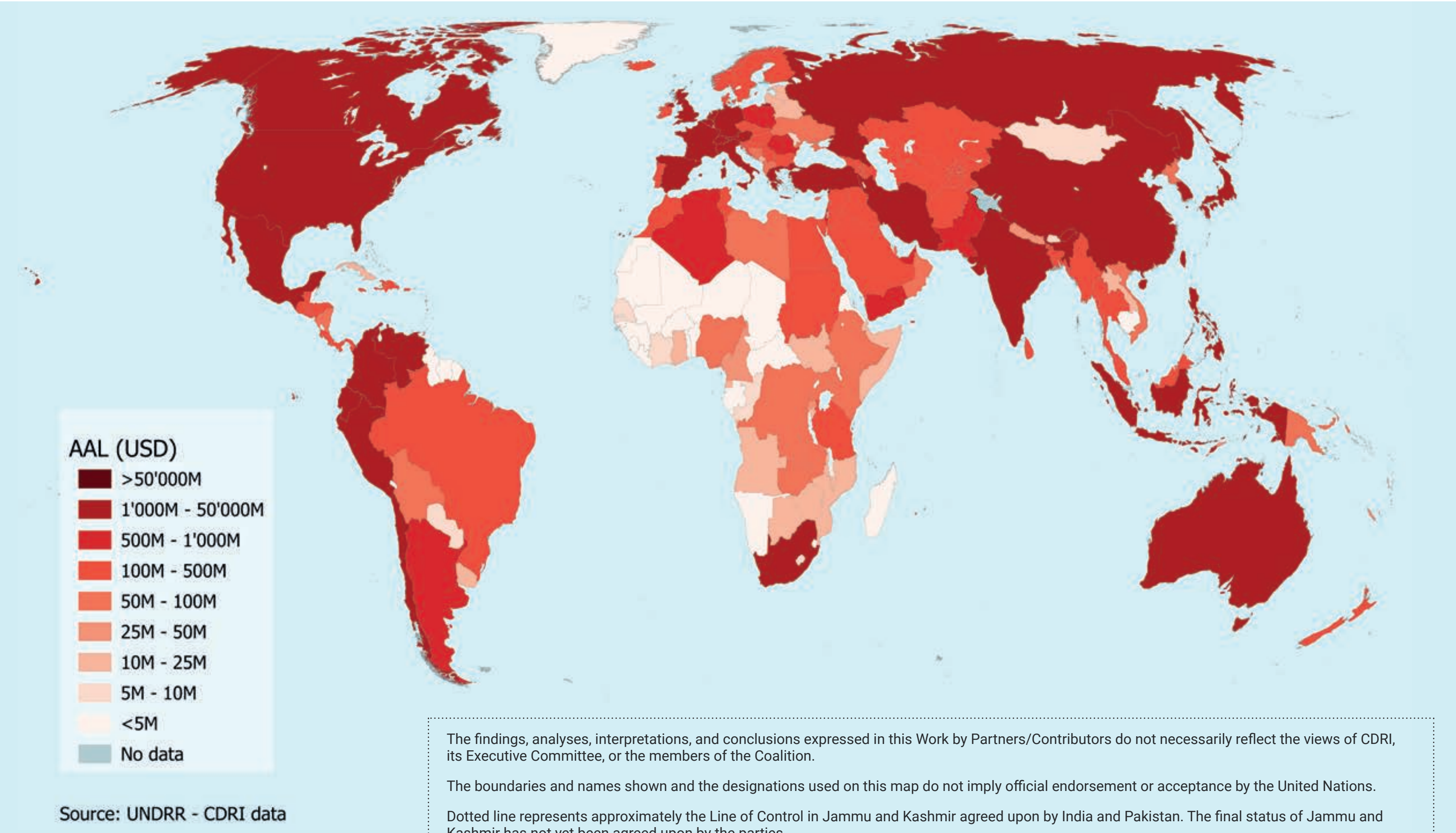


Source: UNDRR based on the data from CDRI (2023)

Earthquakes and tsunamis

Map 24 shows the AAL from earthquakes, including the tsunamis they cause to infrastructure, health and education systems across the world.[32] Globally, the AAL of earthquakes is $87.6 billion in critical infrastructure, $108.5 billion in buildings, $8.5 billion in education and $0.1 billion in health, though these costs are concentrated in specific countries with seismic risk.

Map 24. **Annual average economic losses due to tsunamis and earthquakes combined**



Source: Data: CDRI, 2024:
Cartography: UNDRR

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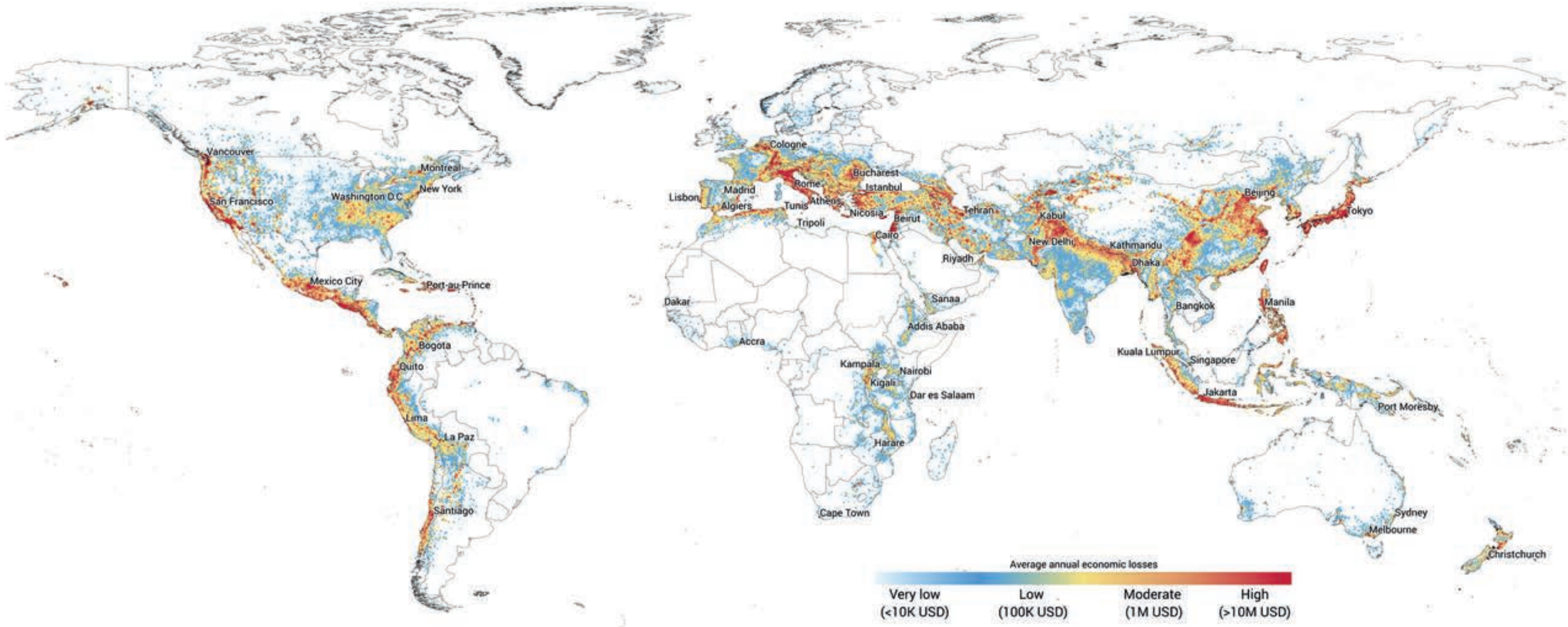
However, earthquake impacts are highly localized within countries. As such, downscaling risk data to the sub-national level can give an even more accurate baseline to guide targeted resilient investment. For example, Map 25 employs a slightly different modelling methodology to provide a more targeted analysis of the earthquake risk sector at a more granular geographic scale. It does not cover all sectors, such as power networks, examined in the table above. But it is innovative in that, in addition to assessing impacts to residential, commercial and industrial buildings, it also includes estimates of displacement, human mortality and supply chain disruption costs, which together suggest a total AAL figure for earthquakes of $85 billion annually.

Map 25. **Annual average economic losses due to earthquakes ($)**



Source: Data: V. Silva, A. Calderon, M. Caruso, C. Costa, J. Dabbeek, M.C. Hoyos, Z. Karimzadeh, L. Martins, N. Paul, A. Rao, M. Simionato, C. Yepes-Estrada, H. Crowley, K. Jaiswal (2023). Global Earthquake Model (GEM) Seismic Risk Map (version 2023.1), https://doi.org/10.5281/zenodo.8409623.; Cartography: GEM Foundation, 2024

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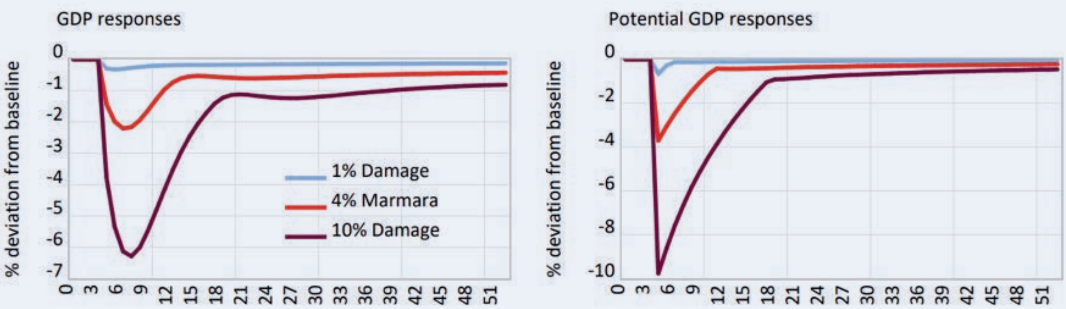
This approach can also help to understand how decisions to invest in building seismic resilience may prevent direct losses and help curtail possible cascading impacts in a broader economy in areas such as credit scores (Box 21).

Box 21. The long-term economic impacts of the 1999 Marmara earthquake, Türkiye

Disasters can have far-reaching consequences on economic systems, extending well beyond the immediate destruction of infrastructure and capital stock. This was highlighted by the fallout from the 1999 Marmara earthquake in Türkiye, which struck the industrial northwest region with a magnitude of 7.8. The shock resulted in extensive destruction, particularly to infrastructure and buildings, causing damage equivalent to 4% of the total infrastructure stock, estimated at $6.5 billion. [33]

While immediate GDP losses were reported at approximately 1.5% for the year of the event, the long-term effects on potential GDP were far more significant. Potential GDP, which reflects the economy's productive capacity, declined by over 4%, highlighting the structural damage to critical infrastructure and its cascading impacts on productivity. Reconstruction challenges prolonged the recovery period, with estimates suggesting it took the economy six to eight years to recover.

Figure 34. **Sensitivity of economic response (GDP and inflation) to capital losses of different intensity, including a loss illustrating the 1999 Marmara earthquake**



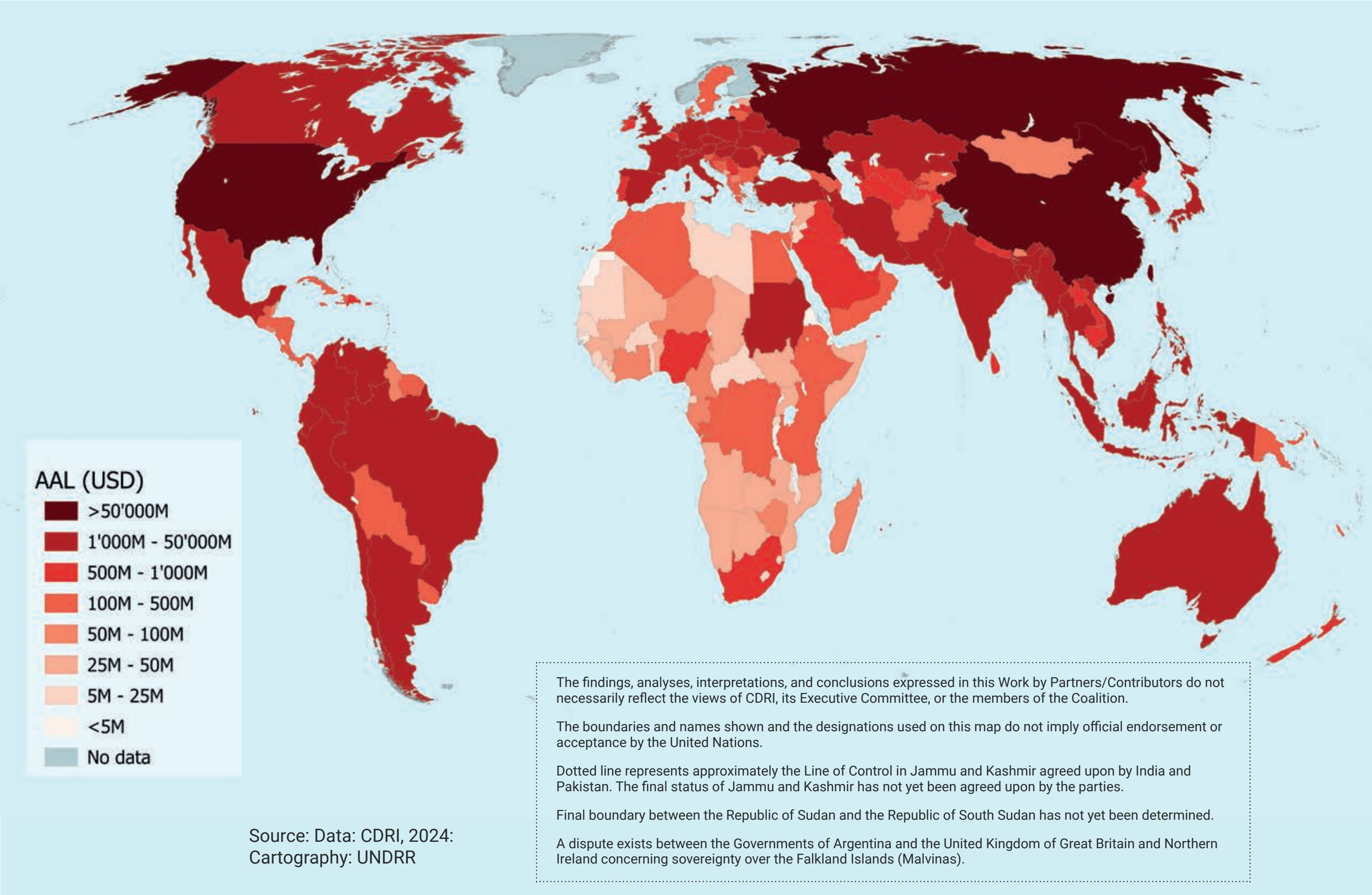
Source: Hallegatte et al (2022)

The implications of these losses were wide-ranging, given that the earthquake struck a region contributing to nearly 35% of Türkiye's GDP, with the manufacturing, trade and export sectors most heavily impacted. Infrastructure losses, including damaged transport networks, ports and power systems, constrained production and slowed economic recovery. This reduction in productive capacity underscored the links between infrastructure and non-infrastructure assets. Even the remaining undamaged capital assets could not operate efficiently without supporting systems like transport and power grids. Türkiye's recovery was further complicated by pre-existing financial vulnerabilities and institutional constraints. Reconstruction investments also diverted resources from new productive capital, slowing long-term growth.

Floods and storms

Probabilistic approaches can also help understand flood risk over time, beyond the specific fluctuations that may occur from year to year. Providing a consistent metric to measure and compare potential damages annually can help guide decisions about flood protection and land use, particularly in the context of climate change and rapid urbanization. This is crucial given that riverine and overflow floods are the costliest of the three hazard types covered here, with average annual losses of $388.4 billion, including $74.1 billion in infrastructure.[34] Meanwhile, the AAL from tropical cyclones is estimated at $119.5 billion, including $95.5 billion in infrastructure.[35]

Map 26. **AAL by floods and cyclones within the critical infrastructure sectors**



Source: Data: CDRI, 2024:
Cartography: UNDRR

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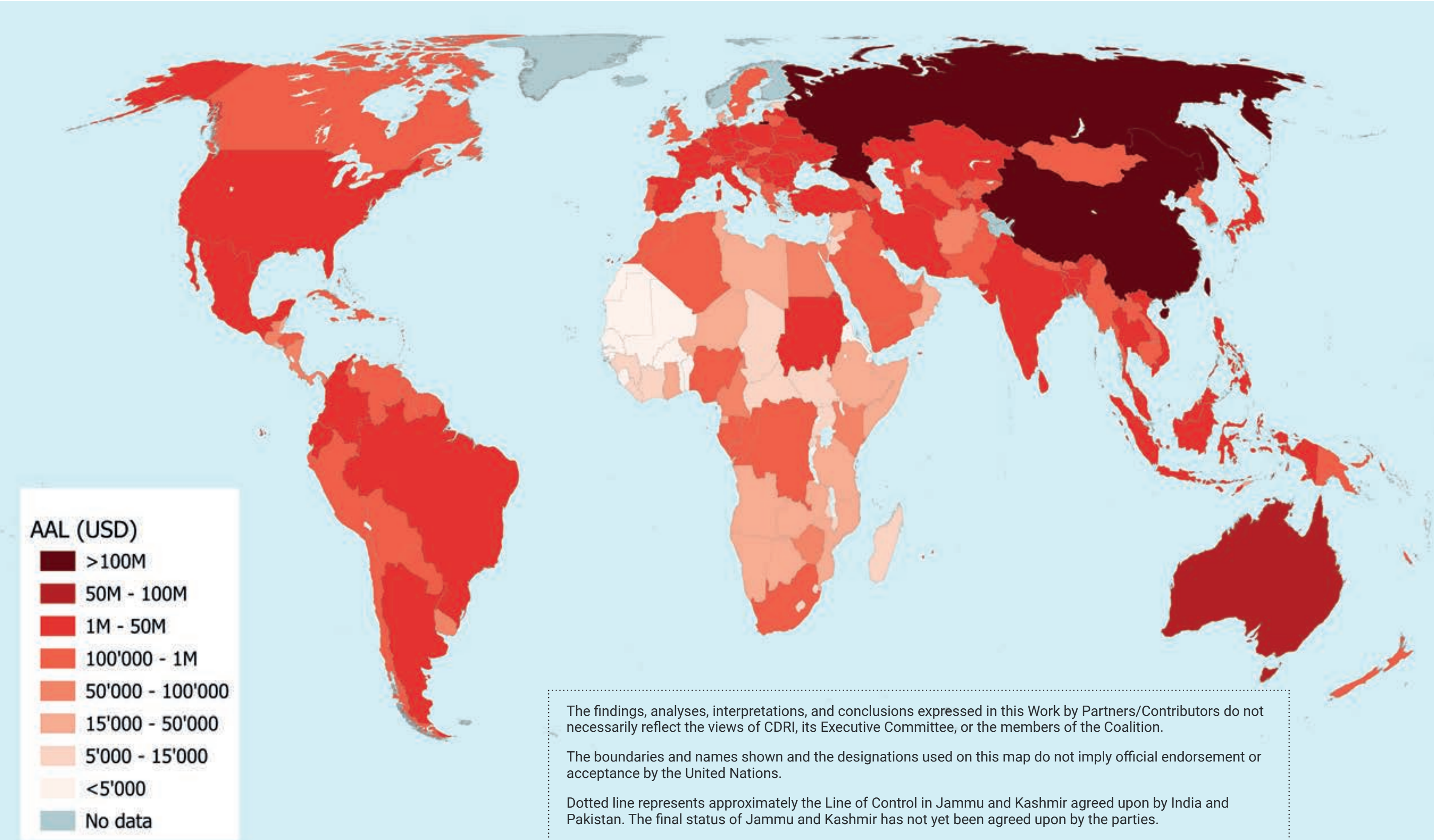
As outlined in Chapter 3, floods and storms also have a wide range of indirect impacts that can hold back development. For example, recently, modelling of the effects of climate-related disasters in Bangladesh explored how these affected access to infrastructure and slowed progress on the Sustainable Development Goals SDGs. The study found the poor were disproportionately at risk in coastal districts. It estimates that targeting climate adaptation towards these at-risk communities could help safeguard 50–85% of achieved progress across a range of key SDG indicators.[36]

For example, Map 27 and Map 28 look at the AAL from floods on just two SDG areas (health and education), considering the impacts on infrastructure and some of the wider indirect and cascading costs.

Map 27. **AAL of floods and cyclones in the health sector**



Source: Data: CDRI, 2024:
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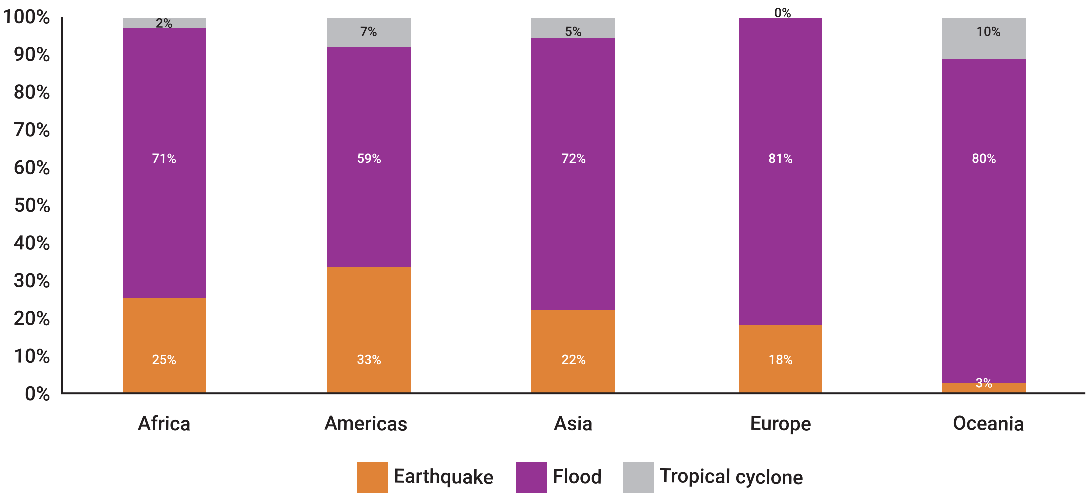
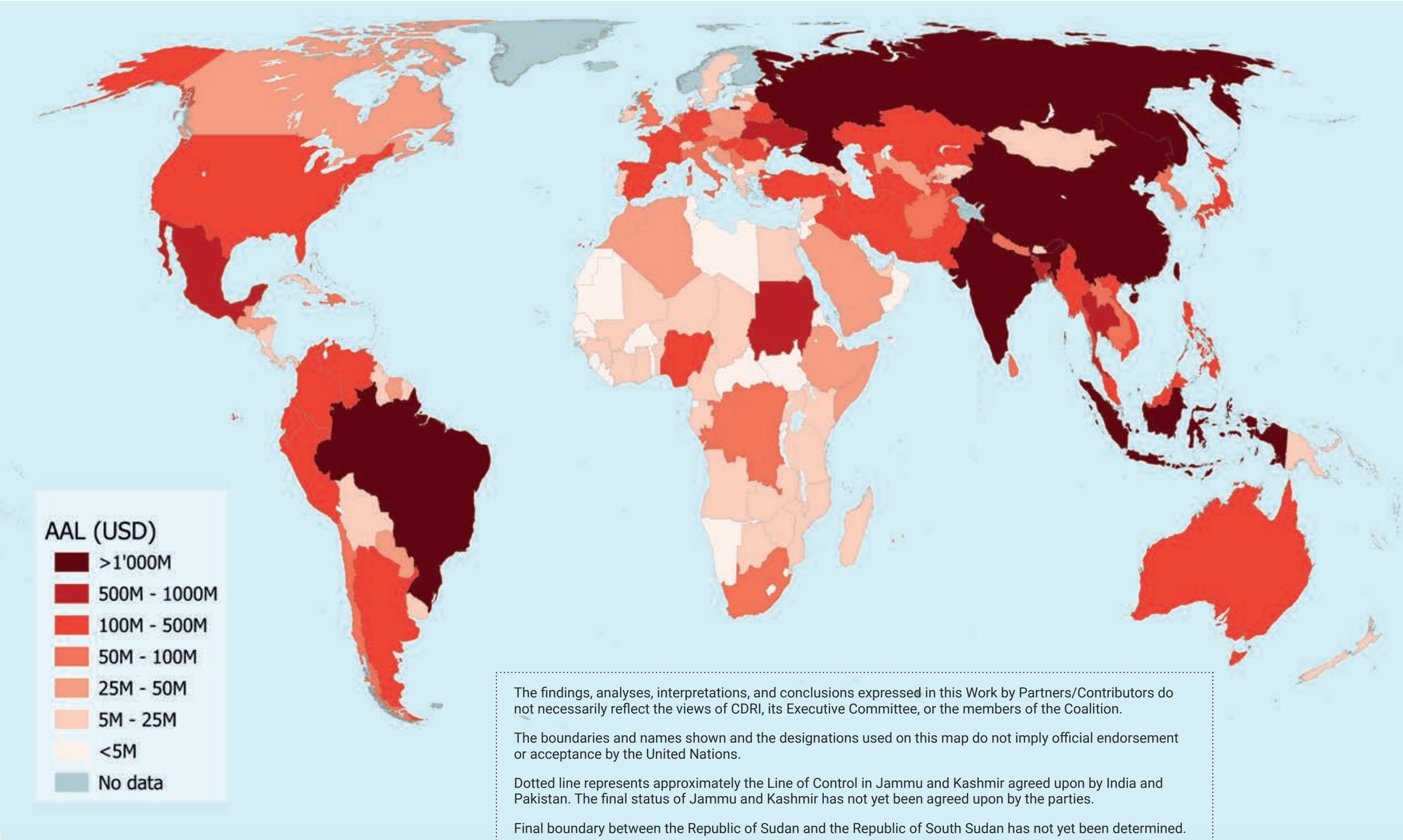
Floods and cyclones pose a significant hazard for the education sector across all regions, representing most disaster-related AAL (Figure 35). Totalling $27.3 billion globally, their combined AAL comprises more than three-quarters of the $35.9 billion AAL for education across all disaster types.[37] Of these, the overwhelming majority (94%) is attributable to floods ($25.6 billion), with the remainder ($1.7 billion) attributable to tropical cyclones.

Figure 35. Percentage distribution of the AAL of the education sector by hazard type and region (current climate scenario)



Source: UNDRR based on data from CDRI, 2024

Map 28. **AAL from floods and cyclones in the education sector**



Source: Data: CDRI, 2024:
Cartography: UNDRR

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Over half ($165.8 billion) of the total $295.5 billion in disaster-related AAL (including landslides and tsunamis) within the critical infrastructure sectors is attributable to floods and cyclones.[38] Cyclones are responsible for $91.7 billion (55%) of these losses, with the remainder ($74.1 billion) attributed to floods. Within regions, AAL for critical infrastructure due to floods and cyclones is 68% for Oceania, 40% for Europe, 53% for Asia, 65% for Africa and 68% for the Americas.

Box 22. Reducing Costa Rica's economic vulnerability to tropical cyclones

Costa Rica faces significant challenges due to tropical cyclones. Historically, these have wrought widespread damage to the economy, infrastructure and communities.[39] From Hurricane Joan in 1988 to Hurricane Eta in 2020, the country has lost over $2 billion in damages, with the Pacific Basin municipalities such as Osa, Pérez Zeledón and Buenos Aires being the most vulnerable.[40] These areas are frequently affected by direct and indirect impacts of tropical cyclones that, together with limited economic resources and inadequate infrastructure, make them highly susceptible to damage.[41]

More than half of these economic losses have been to road infrastructure. Cyclones frequently damage roads and bridges, disrupting transportation networks and daily life. Agriculture, another key sector, has suffered significantly, with major crops such as oil palm, coffee, rice, bananas anFd sugarcane vulnerable to extreme weather conditions, with a cascading effect on rural economies. Similarly, housing and health services have been heavily affected by tropical cyclones over the last three decades. There is a pressing need for land use regulations to reduce these impacts, linked with better scaled risk mapping.[42]

Costa Rica aims to improve scientific analysis to strengthen early warning systems for floods and improve analysis of how earthquakes can trigger heightened landslide risk as part of efforts to build disaster resilience in the face of increasingly severe disaster-related risk.[43]

Hurricane damage in Limon harbour town, Costa Rica

Credit: Shutterstock, Ramunas Bruzas

Drought and extreme heat

Remarkably, despite their significant and growing impacts, studies have provided estimates for specific sectors, but robust cross-sectoral AAL estimates for drought and extreme heat are still missing. For instance, recent research by the United Nations Convention to Combat Desertification (UNCDD) on droughts highlights how they weaken agricultural production, reduce water availability and compromise the resilience of natural ecosystems, affecting the livelihood of more than 1.8 billion people annually.[44] Initial work has been done by CDRI to estimate the AAL of drought on the hydro-power sector, suggesting that roughly 12.9% of average hydro-power production (the equivalent of 135.3 TWh/h of electricity) was impacted.[45] Similar estimates for other drought-sensitive sectors would help countries design better risk reduction policies and investments.

New ways to model the costs of the missing millions

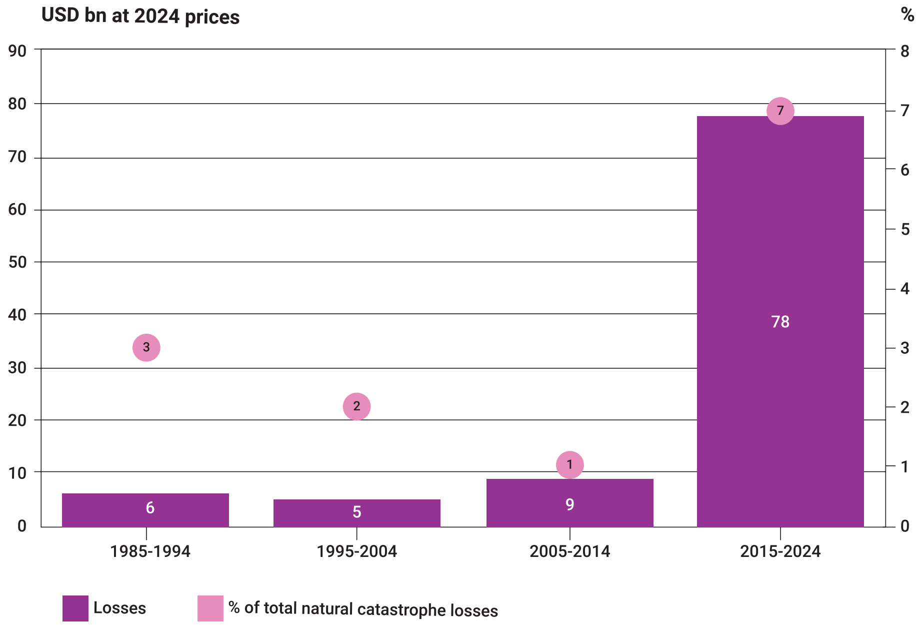
As the gap in drought analysis above attests, AAL calculations are only applied systematically to a small subset of hazard types. Their analysis also tends to focus on calculating losses to infrastructure, such as public assets and critical public assets such as roads, schools and health facilities. This risks overlooking many hazards, such as wildfires and the complex and wide-ranging ways these impacts are felt, and growing in significance due to climate change.

The increasing economic impact of wildfires

Over the past decade, global insured wildfire losses have far surpassed previous records. Although wildfires in the United States (particularly California) make up most of the losses, wildfires in Canada, Australia and Europe have also contributed significantly.

Due to intense development and high value of property in wildfire-exposed areas, the United States is the most economically exposed country to this hazard. Indeed, 9 of the 10 most expensive wildfire events since 1970 occurred in the United States (not yet accounting for the devastating January 2025 California wildfires). From 2014 to 2023, wildfires globally cost approximately $106 billion in economic losses and $74 billion in insured losses, significantly higher than losses in the decade before (Figure 36).[46] Increasing wildfire losses for insurers have caused some to curtail property coverage in heavily impacted areas. This concerning trend will be discussed in more detail in Chapter 6 of this report. Developing a clearer picture of wildfire AALs and PMLs in vulnerable areas could better inform planning decisions in the future. It could help build more innovative risk financing tools, such as parametric insurance to cover at-risk housing, an area discussed in more detail in Chapter 6.

Figure 36. **Global insured losses from wildfires**



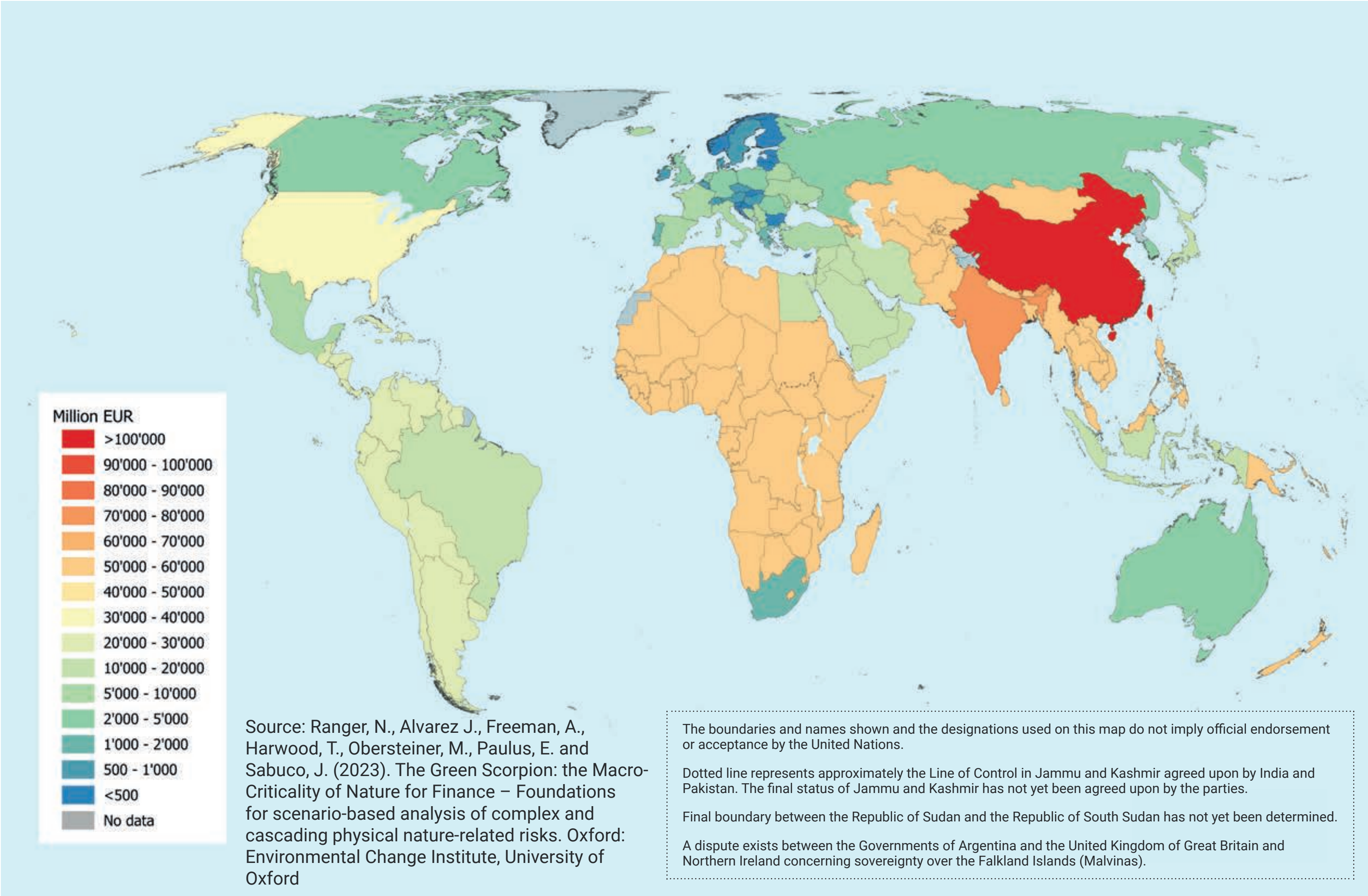
Source: Swiss Re Institute

Understanding the growing cost of natural capital loss

There is increasing recognition that disasters can exact considerable economic losses through damage to infrastructure, housing and other investments, and their impact on ecosystems. In this regard, economic and environmental wellbeing are intertwined. Globally, approximately $44 trillion of economic output (more than half of the global GDP) is moderately or highly reliant on natural capital.[47] An Organisation for Economic Co-operation and Development (OECD) analysis suggests that the planet has been losing $4–20 trillion annually in ecosystem services owing to land-cover changes and a further $6–11 trillion from land degradation.[48] Various disaster risks threaten to compound these threats and are already exacting considerable losses that are typically overlooked.

Map 29 was developed with the Network of Central Banks and Supervisors for Greening the Financial System (NGFS) to estimate a metric known as the nature value at risk (nVaR) for countries, sectors and various ecosystem services to the agriculture sector.[49] This measurement highlights the often unacknowledged long-term economic implications of natural capital depletion. According to NGFS' calculations, the scale of 0.01 nVaR (1-in-100-year) risk worldwide is as much as 16% of global GDP, with the United States and China standing out as countries with the highest absolute nVaR

Map 29. Country-level nature Value at Risk (nVaR) to the agricultural sector



Source: Ranger, N., Alvarez J., Freeman, A., Harwood, T., Obersteiner, M., Paulus, E. and Sabuco, J. (2023). The Green Scorpion: the Macro-Criticality of Nature for Finance – Foundations for scenario-based analysis of complex and cascading physical nature-related risks. Oxford: Environmental Change Institute, University of Oxford

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.

A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

The value of the nVaR measurement takes a broader perspective on nature loss, accounting for the immediate impacts of environmental damage and known effects (for instance, the economic losses in agriculture, manufacturing and other sectors due to water-related risks). The analysis suggests that, without stepped-up action to build resilience and stabilize ecosystems, disaster-related costs could account for over 1% of global GDP by 2050, with more severe impacts in lower-income nations where resilience gaps and limited resources exacerbate vulnerabilities.[50] Such losses would significantly disrupt development and global trade, deepen socio-economic inequalities and increase debt and dependencies on external aid, particularly in developing regions.

However, these costs also highlight that investing in environmental resilience can reap significant dividends in averted losses, making it a sound investment from an economic perspective. While the estimated cost of achieving significant land restoration by 2030 globally is more than $300 billion annually, the investment would repay itself many times over.[51] According to estimates, $1 invested in restoring degraded land could return $7–30 in economic benefits.[52] Land restoration and sustainable crop and rangeland management are often the most cost-effective methods for halting or reversing desertification, and the benefits of acting against land degradation vastly outweigh the costs of sustainable landscape management.

Indirect economic impacts on food systems

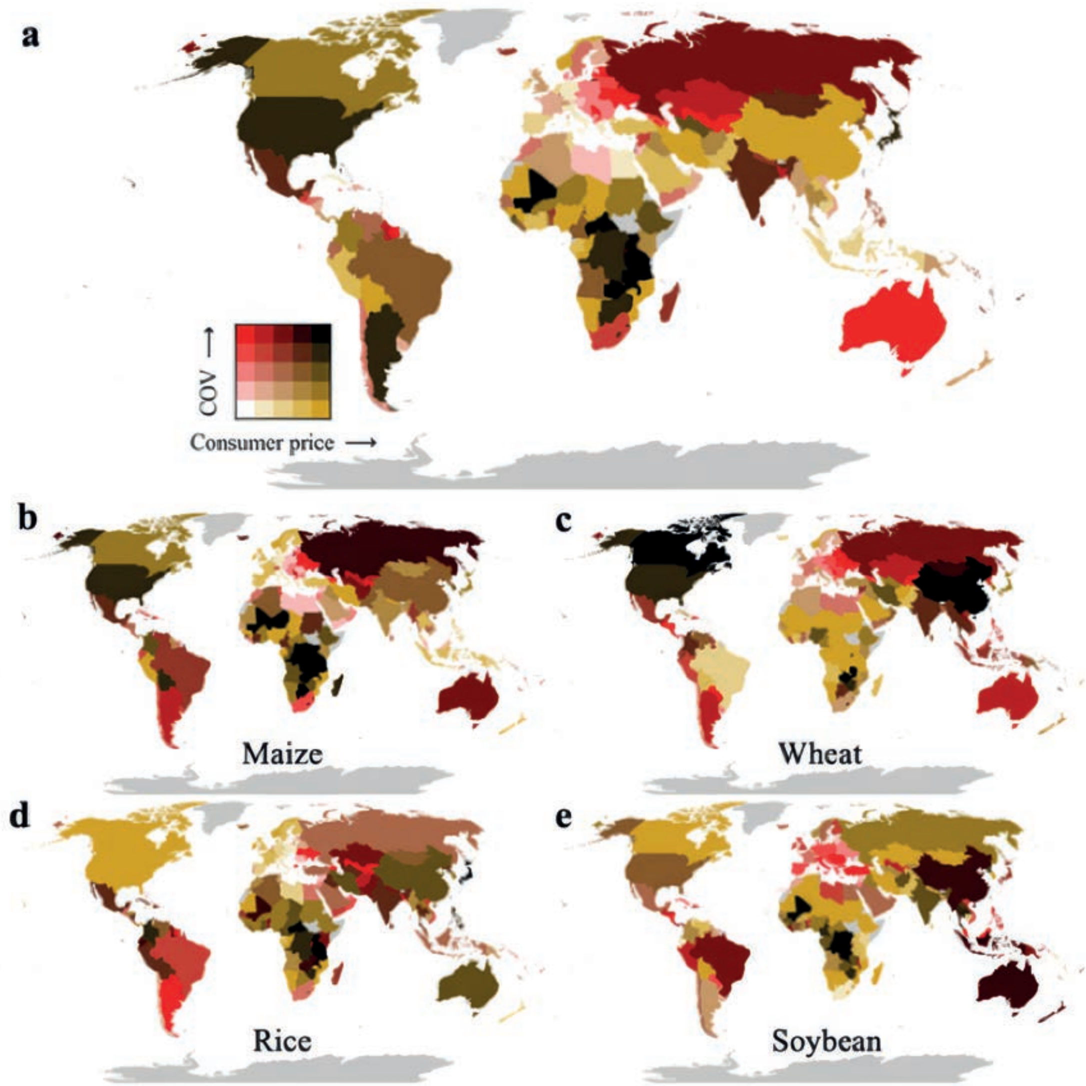
In a more globalized world, the impact of disasters on the price of food is often determined by far more than just the cost of production. Increasingly, food security comprises four elements: availability, access, utilization and system stability over time. Factors such as fluctuations in the cost drivers of internationally traded food can determine access and affordability. The costs of sourcing imported food differ considerably between and even within countries.

While global agricultural and food trade has dramatically expanded in recent decades, helping reduce food insecurity by providing year-round access to food, this connectivity also involves managing supply chains and other risks. Volatility in food prices can be driven by a range of factors, including differences in the production costs across exporting regions, tariffs and trade agreements, transport costs, border compliance costs and non-tariff barriers.[53] Transport costs can also exert an outsized impact on global food prices. For example, maritime transport costs are 5–15% of the total cost of grains and oilseeds at the importing port (the cost from the field to the importing port). Transport inland adds significantly to that cost, particularly in developing and landlocked countries. High transport costs can be an important trade friction limiting trade, preventing certain regions from reaping the benefits of access to international markets.

Understanding how climate events may impact food security is not as simple as understanding the extent of a drought or the percentage of crops destroyed after a flood. However, models are improving the understanding of how these impacts interact with trade and transport markets, providing valuable policy-making insights. The graphics in Map 30 have been developed based on models that aim to simulate these complex and intersecting dynamics on the prices of the world's most prevalent food staples (maize, wheat, rice and soybean). These models project the impacts of various hazard-related risks and other shocks, including energy price hikes, imposed trade bans and a compound polycrisis shock. Looking at the period from 2017-2021, the analysis finds that the compound shock results in a 23–52% increase in consumer prices and a resultant 7.3¬% to 16.5% loss to consumers. The total negative consumer losses can be over $600 million in a single year, affecting virtually all countries simultaneously.[54]

Map 30 shows how countries in landlocked sub-Saharan Africa, South America, East Asia and Oceania face disproportionately high landed costs, though the factors that drive these costs differ. For instance, countries in the Pacific face high landed costs given the distance to export markets, resulting in high maritime transport costs. Landlocked countries in sub-Saharan Africa and South America have disproportionately high hinterland transport costs, adding to the total landed cost. In East Asia, high import tariffs add significantly to landed costs.[55] This kind of analysis can help policymakers identify critical bottlenecks and opportunities to reduce risk in their food systems. It can also help build models that can better account for vulnerabilities in future supply chain systems, thereby guiding efforts to build resilience and reduce the potential for price volatility.

Map 30. **Weighted average landed cost for maize, wheat, rice and soybean for the 2017–2021 trade network**



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Source: Jasper Verschuur et Al, (2024), "The impacts of polycrises on global grain availability and prices¨, Environmental Change Institute - University of Oxford, https://doi.org/10.21203/rs.3.rs-3969801/v1.

Estimating the economic cost of internal displacement

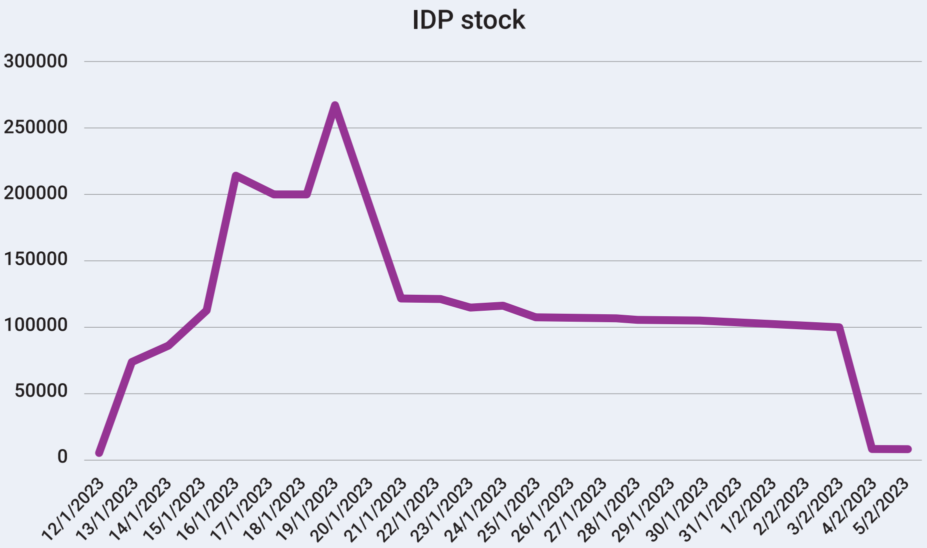
As discussed earlier in this report, the destabilizing impacts of disaster-related displacement can lead to a deterioration in health, security, social life, housing conditions, livelihoods, environment and education of those affected. All of these dimensions limit the ability of internally displaced people (IDPs) to lead healthy lives, but they also have considerable economic impacts. Applying the concept of "disability adjust life years" (DALYs) can help in understanding how displacement has longer-term social and economic implications for wellbeing (see Box on DALYs in Chapter 3). The DALY measurement has been adapted to assess the economic impacts of internal displacement during the major floods experienced in the Philippines in 2023.

Box 23. Assessing the economic costs of internal displacement in the Philippines in the January 2023 floods

The Philippines is notable for its consistent and systematic displacement data, which help the country identify and respond to disasters effectively. These data, which record the total number of people displaced and the duration of displacement in both evacuation centres and outside, provide a vital resource to calculate wellbeing losses in the wake of disasters.

This case study examines the impacts of severe flooding at the beginning of 2023. Figure 37, drawing on data from the Philippines National Disaster Risk Reduction Management Council (NDRRMC), shows that the total number of people internally displaced between 12 January and 5 February in around 14 regions of the country was 266,349.

Figure 37. Number of IDPs and duration of displacement due to flooding in the Philippines, 2023



Source: IDMC, 2024

Estimating the duration of displacement based on the number of people registered in evacuation centres and outside (that includes those staying with family and friends) provides an average of 11 days of inactivity due to internal displacement. These households may have experienced an extended period of inactivity exceeding the estimated 11 days, based on reported days of stay in either evacuation centres or with family and friends. Based on the above, the total life-years lost during the floods were estimated at 7,940. Converting it to monetary value represents a loss of economic productivity of $87 million.

This figure accounts for the productivity lost by households whose duration of displacement is estimated using stay in evacuation centres and with host communities. However, it does not account for longer periods of displacement, especially for those whose homes were destroyed: based on reported damages, 562 houses were completely destroyed. In addition, these costs do not include the psychological toll of this event, which can further reduce productive capacity and increase the number of life-years lost. Assuming those with housing destruction would remain displaced for up to a year can further increase the total losses to around 10,300 life-years, increasing the loss of economic productivity to as much as $114 million, around 31% higher than the initial estimate.

Estimating the impacts of internal displacement in social and economic terms is complex, as this brief snapshot illustrates, while these numbers are indicative, they point to the considerable, under-reported impacts on lives and livelihoods that floods have around the world.

Ways forward

This chapter has shown that the economic costs of disasters are massively undercounted, but so are the benefits of investing in resilience building. While disaster risk cannot be eliminated, the impacts can be greatly reduced through informed investment and future-oriented decision-making. There is a clear opportunity to do more.

Disaster risk reduction has a clear amplifier effect in accelerating sustainable development. For example, ensuring schools are not built in flood zones can reduce the number of school days missed and help educational outcomes. However, that same investment can also reduce potential fatalities and double up as a store for seed supplies, helping to speed recovery in case of a nearby hazard event. Protecting critical public infrastructure from damage or destruction makes these more cost-effective investments, meaning governments do not have to incur debt to rebuild after major hazards.

This positive impact of risk reduction on fiscal stability is most clearly evidenced in smaller economies where losses from a single disaster event can immediately and significantly wipe out growth and increase debt, and in doing so contribute to a lowering of credit ratings.

Disaster risk reduction investment is seldom explicitly considered as a core component of infrastructure or development investment. For example, an analysis of more than 4,000 infrastructure projects in 2019–20 found that climate resilience was a very small fraction of total infrastructure investment in the water, wastewater, transport, energy, agriculture, forestry and land-use sectors. In terms of tracking resilience-building investment, "for every $1 spent on climate-resilient infrastructure, $87 was spent on infrastructure projects that did not integrate climate resilience principles".[56] Investment in seismic resilience also lags far behind what is needed.

- As hazard risk increases, so does pressure on development budgets. Investment patterns and social policies must evolve to use disaster risk reduction to become more effective.
- Policy makers must wake up to the amplifier effect of disaster risk reduction at the national and household level. The evidence is clear that preventing disaster losses helps families stay out of poverty. Planning early to reduce risk and ensuring safety nets are in place to help the poorest recover quickly if they are affected by a disaster has long-term benefits that far outstrip their costs.
- Policy makers and citizens must get used to using this information actively in their investment decision-making. Using probabilistic models to better understand the risk of hazard, multi-hazard and cascading disasters helps turn perceived volatility or uncertainty into probabilities that can be managed like other financial risks. Understanding historical losses and average annual and probable maximal losses can give powerful insights into where investments in DRR can be most effective. Such analysis must move to understand the relationships across hazards and to better consider the impact of social policies and human behaviour on recovery.

- At the asset level, policymakers and investors must start mandating that infrastructure investments are designed in ways that minimize their exposure to excessive current or future hazard risk. Building codes, zoning restrictions and other regulatory instruments are effective tools to guide more resilient development. Businesses should also be educated on the clear cost-benefits of mainstreaming disaster risk reduction into their investments, with any initial outlays to strengthen resilience likely paid back many times through averted losses.

- Policies to help households cope better and recover quicker in light of disasters must become integral tools in wider fiscal planning. Not only do they help reduce poverty, but they are also the first line of defense in reducing GDP losses and debt accumulation. Where possible, this can be facilitated by increasing access to risk transfer tools that can share the financial burden of household-level losses across the public and private sectors or regions. Innovative risk transfer and/or insurance programs that provide at-risk households with affordable coverage against disasters can also play a crucial role in speeding recovery and safeguarding wellbeing.

- At a country level, governments can enact adequate risk-informed fiscal policies, recognizing not only direct disaster impacts but also the implications of cascading impacts, such as nature loss, migration risk and issues such as supply chain disruptions, and their potential knock-on effects on inflation and food security. Once all these costs are factored in, it is likely that any investment in disaster risk reduction will be even more cost-effective.

- At the global level, international financial institutions and multilateral organizations must do more to ensure that disasters are not perceived as unforeseen shocks, but as financial and systemic risks to be managed. Systems need to evolve so that tools like the IMF's Special Drawing Rights – a reserve asset that can provide much-needed liquidity to countries at times of crisis can support more disaster risk reduction and climate action to help lower-income countries build fiscal resilience to multiple hazards, including earthquakes and tsunamis.

- Ultimately, investing in disaster resilience is not just a moral imperative. It is a smart economic choice. These investments can bolster regional prosperity and safeguard development gains in the face of escalating risks. The next chapter looks ahead to 2050, examining how different choices, especially around climate resilience, will shape our future. Without strengthened resilience measures, climate-related and compound disasters could reduce GDP per capita by up to 10% in some regions. With better risk understanding and well-targeted investments, countries can better anticipate and mitigate these risks, unlocking high returns while avoiding major social and environmental losses.

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[1]UNDRR using data from EM-DAR, CRED / UCLouvain, 2025. Extracted 3 March 2025.

[2]UNDRR using data from EM-DAR, CRED / UCLouvain, 2025. Extracted the 27 February 2025.

[3]These figures are derived from the DesInventar and EM-DAT disaster databases: both provide a conservative estimate of direct losses as many entries in those databases have no associated impact/losses.

[4]World Meteorological Organization, 2021

[5]UNEP and Coalition for Disaster Resilient Infrastructure (CDRI), 2025

[6]Thomas et al., 2024

[7]CRED and UCLouvain 2025. Extracted the 22 January 2025.

[8]Jeong, Yu and Cannon, 2024

[9]National Centers for Environmental Information (NCEI), 2021

[10]Vincent, 2025

[11]UNDRR using data from EM-DAR, CRED / UCLouvain, 2025. Extracted the 22 January 2025.

[12]Borg et al., 2021

[13]Idem

[14]García-León et al., 2021

[15]Marcotullio, Keßler and Fekete, 2022

[16]FAO, 2023

[17]Note: detailed methodology in Annex I.

[18]Data Souces: CRED and UCLouvain, 2025. Extracted 22 january 2025; Desinventar, 2025. Extracted 26 February 2025; World Bank, 2025. Extracted 22 January 2025; WHO, 2024; IDMC, 2024; Roy et al., 2024; FAO, 2023; Nkonya, Mirzabaev, and Von Braun, 2016; UNCCD, 2024; Aze, Barry, and Bellerby, 2014.

[19]UNDRR using CRED and UCLouvain, 2025. Extracted 22 january 2025

[20]Intergovernmental Panel On Climate Change (Ipcc), 2023.

[21]A High Resolution Input-Output Model to Assess the Economic Impact of Floods, Di Noia, Caiani et al, 2024

[22]Middelanis, R et al., 2025.

[23]Middelanis, R et al., 2025.

[24]This is because the marginal utility of consumption is higher for poorer individuals: every dollar lost represents a more significant reduction in their ability to meet basic needs, access essential services, and maintain a certain standard of living. A "poor" person, a $100 loss in consumption can have a disproportionately negative effect on their overall wellbeing compared to someone with greater financial flexibility, who typically have a larger buffer and more diverse income sources. This disparity is what the wellbeing loss metric seeks to capture. The same monetary loss can translate into vastly different wellbeing impacts depending on one's socioeconomic status.

[25]Middelanis, R et all., 2025.

[26]Resilient Planet: Data Hub, n.d.

[27]A SDR allocation is a way of supplementing a countries' foreign exchange reserves, allowing members to reduce their reliance on more expensive domestic or external debt for building reserves.

[28]Resilient Planet: Data Hub, n.d.

[29]An AAL is the expected long-term value of losses over a year, calculated as the integral (or summation) of the loss exceedance probability (LEP) curve, averaged over many years (insurance grade models aim for a 1000-year event set, yet not universally applicable).

[30]For the GIRI methodology, critical infrastructure refers to water and wastewater, telecommunications, roads and railways, power, ports and airport as well as oil and gas (but does not include health, education and government buildings).

[31]As these figures are based on aggregate economic losses, these tend to be greatest in higher-income countries with geater unit values for housing, infrastructure and other exposed assets.

[32]This AAL calculation from CDRI aggregates assets into broader categories by dividing them into buildings (which includes a wide range of structures such as residential housing, education centres, healthcare facilities and so forth) and infrastructure (covering assets like roads, utilities and other production-related facilities).

[33]Hallegatte, Jooste and McIsaac, 2022.

[34]CDRI, 2024.

[35]CDRI, 2024.

[36]Adshead et al., 2024. There is significant variation within regions: the AAL for the education sector due to floods and cyclones is 90% for Oceania ($0.38 billion), 81% for Europe ($5.4 billion), 77% for Asia ($15.6 billion), 74% for Africa ($1.6 billion) and 66% for Americas ($4.2 billion).

[37]Source: UNEP and Coalition for Disaster Resilient Infrastructure (CDRI), 2025

[38]CDRI, 2024. For the GIRI methodology, critical infrastructure refers to water and wastewater, telecommunications, roads and railways, power, ports and airport as well as oil and gas (but not including health, education and government buildings).

[39]Case study developed for GAR by Adolfo Quesada-Román, Geographer and Geomorphologist, Universidad de Costa Rica.

[40]Quesada-Román, 2024.

[41]Quesada-Román, Hidalgo and Alfaro, 2024.

[42]Comisión Nacional de Prevención de Riesgos y Atención de Emergencias (CNE), 2021.

[43]Garro-Quesada et al., 2023; Quesada-Román, Villalobos-Portilla and Campos-Durán, 2021.

[44]Thomas et al., 2024.

[45]CDRI, 2023.

[46](adjusted to $2023).

[47]World Economic Forum, 2020

[48]OECD, 2019

[49]Ranger et al., 2023

[50]Ranger et al., 2023

[51]International Union Conservation of Nature, 2011

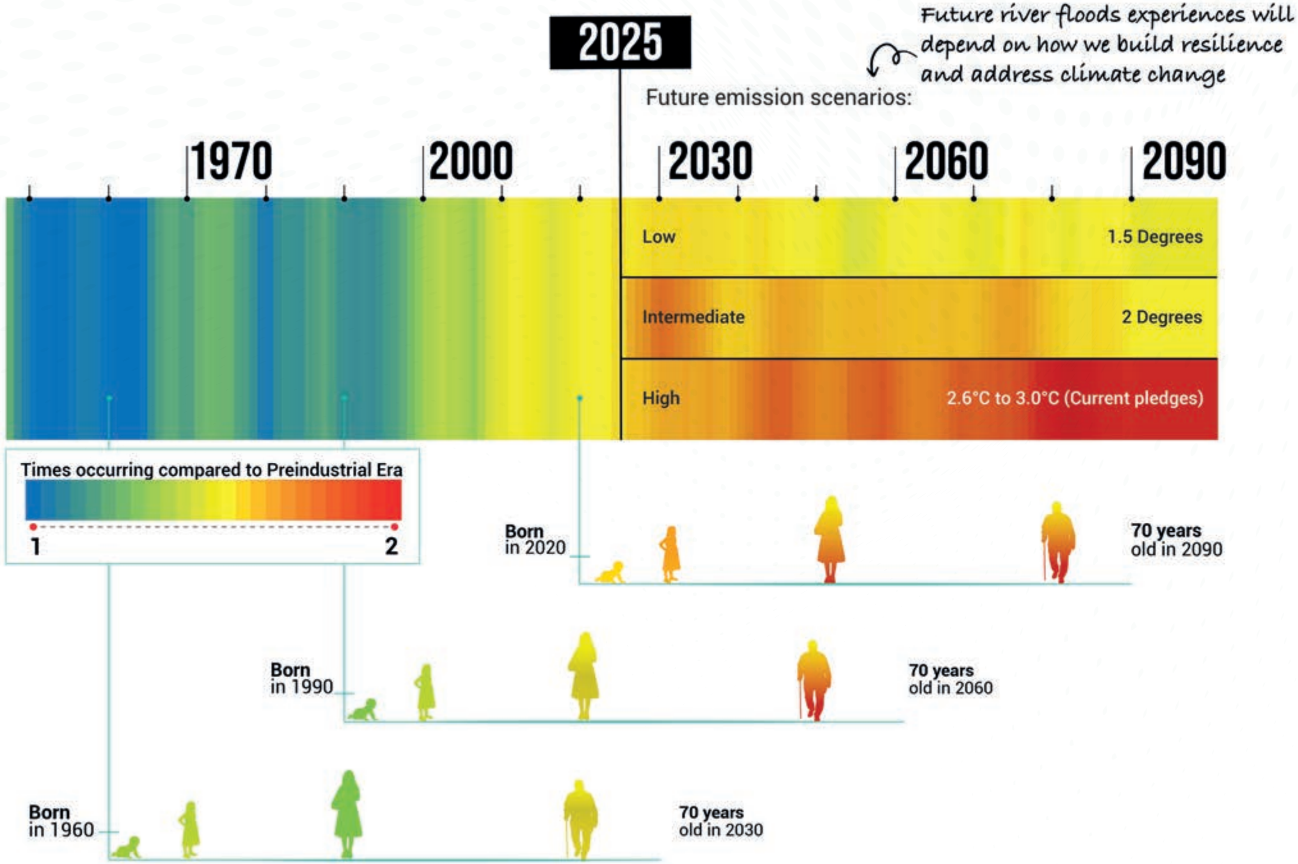
[52]UNCCD, 2024

[53]Zmami and Ben-Salha, 2023.

[54]Verschuur et al., 2025.

[55]Verschuur et al., 2025.

[56]Climate Policy Initiative, 2025.



Future river floods experiences will depend on how we build resilience and address climate change
2025
Future emission scenarios:
1970
2000
2030
2060
2090
Low
1.5 Degrees
Intermediate
2 Degrees
High
2.6°C to 3.0°C (Current pledges)
Times occurring compared to Preindustrial Era
1
2
Born in 2020
70 years old in 2090
Born in 1990
70 years old in 2060
Born in 1960
70 years old in 2030

CHAPTER 5

Future risk and the choices ahead

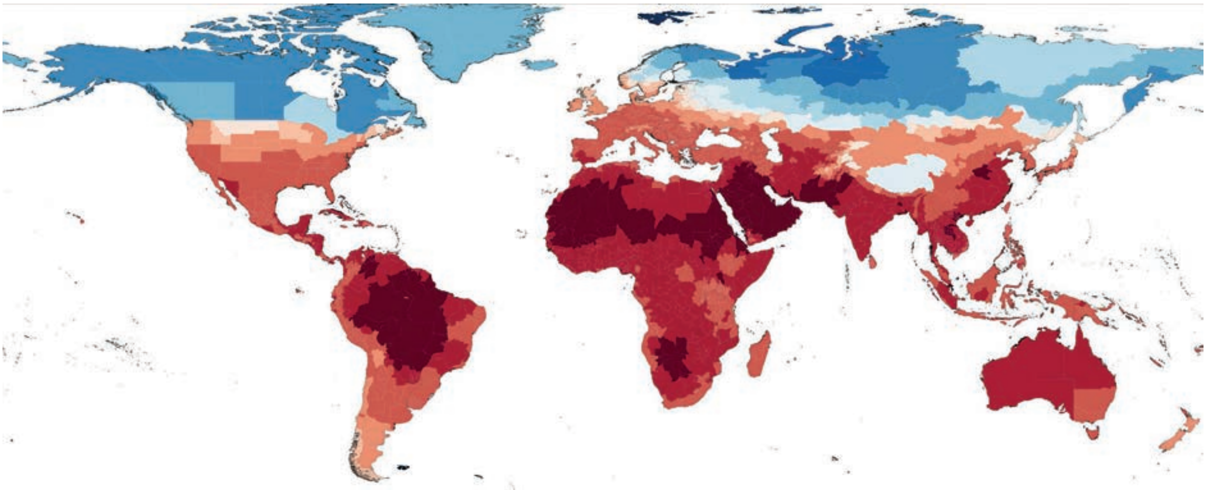
The world faces an increasingly volatile future. As hazard patterns evolve, risk understanding and preventive action are more important than ever. This chapter begins by looking at some of the costliest hazards and their likely future impacts by 2050 in the light of demographic trends, urbanization and two different climate scenarios. Drawing on the recently developed modelling and analytic tools, it provides a clear picture of the deepening losses that could occur if risk creation continues to outstrip risk reduction.

Human choices from energy consumption to land use planning play a crucial role in shaping future vulnerability and exposure. For example, seismic risk is primarily increasing not because the hazard is higher, but because current human action (such as unsafe housing construction in seismic zones) puts more people and assets in harm's way.

While Chapters 3 and 4 focus on the current situation, this chapter explores possible future trajectories and looks at available opportunities to lock into a more positive future trajectory. It highlights the imperative to stop disaster cycles of costly response and slow recovery that hinder long-term economic development and decrease household income growth.

For example, unless disaster risk can be reduced, climate-driven disasters may affect future household income growth significantly by 2050 (Map 31). While the model suggests significant variations between regions, all face reduced income growth of between 11% and 29%. Lower-latitude low-income areas face the most pronounced losses, but all countries would be negatively affected.

Map 31. Total impact of climate-related hazards on household income growth by region by 2050



Source: Kotz, M., Levermann, A. & Wenz, L. The economic commitment of climate change. Nature 628, 551–557 (2024). https://doi.org/10.1038/s41586-024-07219-0

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As with many other aspects of disaster risk reduction, collaboration and risk understanding are key. Foresight must combine quantitative and qualitative techniques, and understanding future risk requires interdisciplinary collaboration between physical scientists, economists and other social scientists. Drawing on the skills of local knowledge holders is essential, but so is engaging the forward-thinking skills of economists, actuaries and insurance risk modellers. Public-private dialogue and collaboration are key. Currently, these disciplines are often disconnected, creating barriers to understanding the economic and broader impacts of climate change and other future risks.[1]

Planning for the future must become a routine part of planning across sectors. For example, with the support of the United Nations Office for Disaster Risk Reduction (UNDRR), the United Nations system is taking steps to strengthen its use of risk analysis to anticipate future risks when designing and implementing development programmes. Using publicly available data, a comprehensive risk analysis looking at the evolution of priority hazards, exposure, vulnerability, and short- and longer-term scenarios, is developed and applied against the Sustainable Development Goals (SDGS). The analysis is jointly validated with partners, and the scenarios are expanded using collaborative foresight methodologies. Increasingly, this process is carried out collaboratively across the humanitarian-development and peace nexus.[2]

Future risk and the costliest hazards up to 2050

Currently, 95% of losses from recorded economic disasters are due to one of the “big five” hazards: earthquakes, floods, storms, droughts and extreme heat.[3] As a result of climate change and other factors, the frequency and intensity of these events are growing for climate hazards. What qualifies as a 1-in-100-year hazard event in 2050 will be more intense than a similar return period event today.

Future earthquake risk

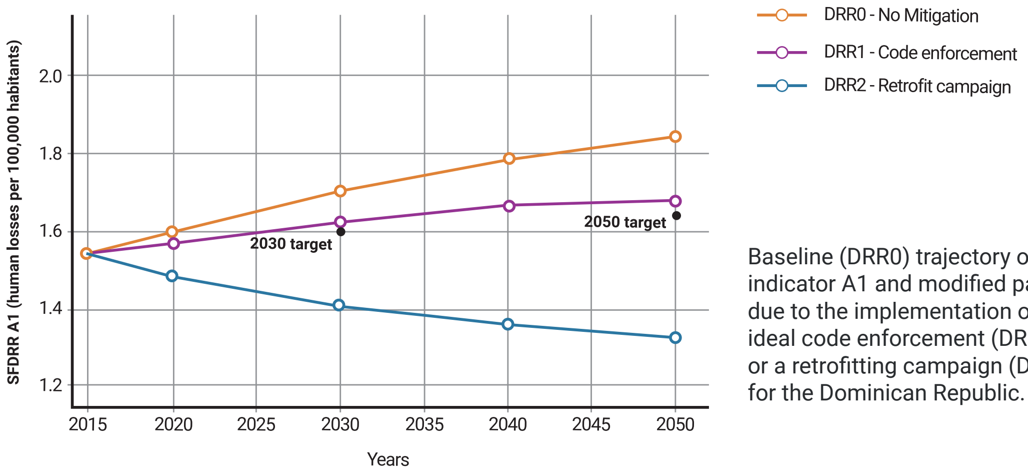
As outlined in Chapter 3, making sound investments to build resilience is highly effective in countering seismic risk. However, in key sectors, such as infrastructure, this is still not frequent enough, meaning more people and assets are left in harm's way. Take the case of the Dominican Republic. In 2015, the country had a baseline average annual loss of 1.55 deaths per 100,000 inhabitants from earthquakes. According to analysis by the Global Earthquake Model (GEM) team, without stepped-up risk reduction action, this is projected to increase to 1.69 deaths per 100,000 people by 2030 and 1.82 deaths per 100,000 people by 2050, mainly due to demographic growth, urbanization and policy choices (Figure 38).[4] While the Dominican Republic has already invested in developing strong seismic codes, it faces challenges in enforcing them and also in retrofitting existing housing stock. However, stepped-up action on seismic risk management could significantly reduce these future impacts.

Solutions vary across locations, but in this case, code enforcement was identified as the most effective long-term mitigation at a national level. This option could reduce the number of deaths to 1.40 fatalities per 100,000 inhabitants by 2030 (a drop of 17%, compared to no action being taken) and 1.33 by 2050 (a reduction of 26%). However, a retrofitting campaign would also have a significant impact, leading to a 4% reduction on the baseline scenario by 2030 and a 7% reduction by 2050. (Maps 32a and b) The investment would be particularly effective in rapidly growing cities with high concentrations of informal construction, such as Santiago de los Caballeros and Puerto Plata.[5]

Figure 38. Projected human losses from earthquakes in the Dominican Republic with no mitigation, code enforcement and retrofitting

Retrofit campaign parameters for the second risk reduction strategy (DRR2) in the Dominican Republic

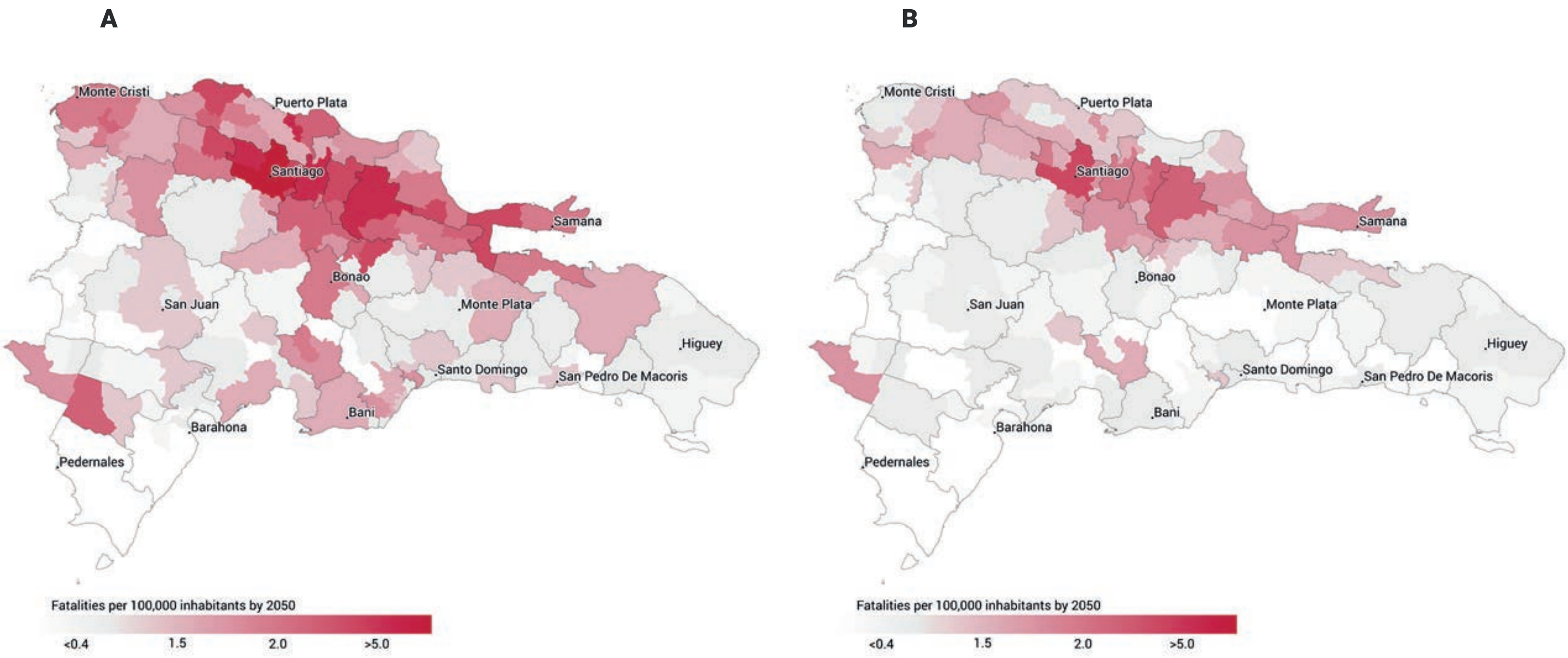
Investment (USD mill.)	Retrofit Technique	Building classes	Cost (USD/m²)	Total cost (USD)	No. Structures
34.4	Ferrocement Ferrocement	MUR/DNO/H1 MUR/DNO/H2	48 48	2880 4464	3583 5394



Baseline (DRR0) trajectory of indicator A1 and modified paths due to the implementation of an ideal code enforcement (DRR1) or a retrofitting campaign (DRR2) for the Dominican Republic.

Source: (Calderon and Silva 2022)

Map 32. Projected average annual fatalities per 100,000 inhabitants by municipality in the Dominican Republic in 2050. (A) Following current growth and construction practices; (B) following nationwide adoption of the seismic code



Source: GEM Foundation, 2024

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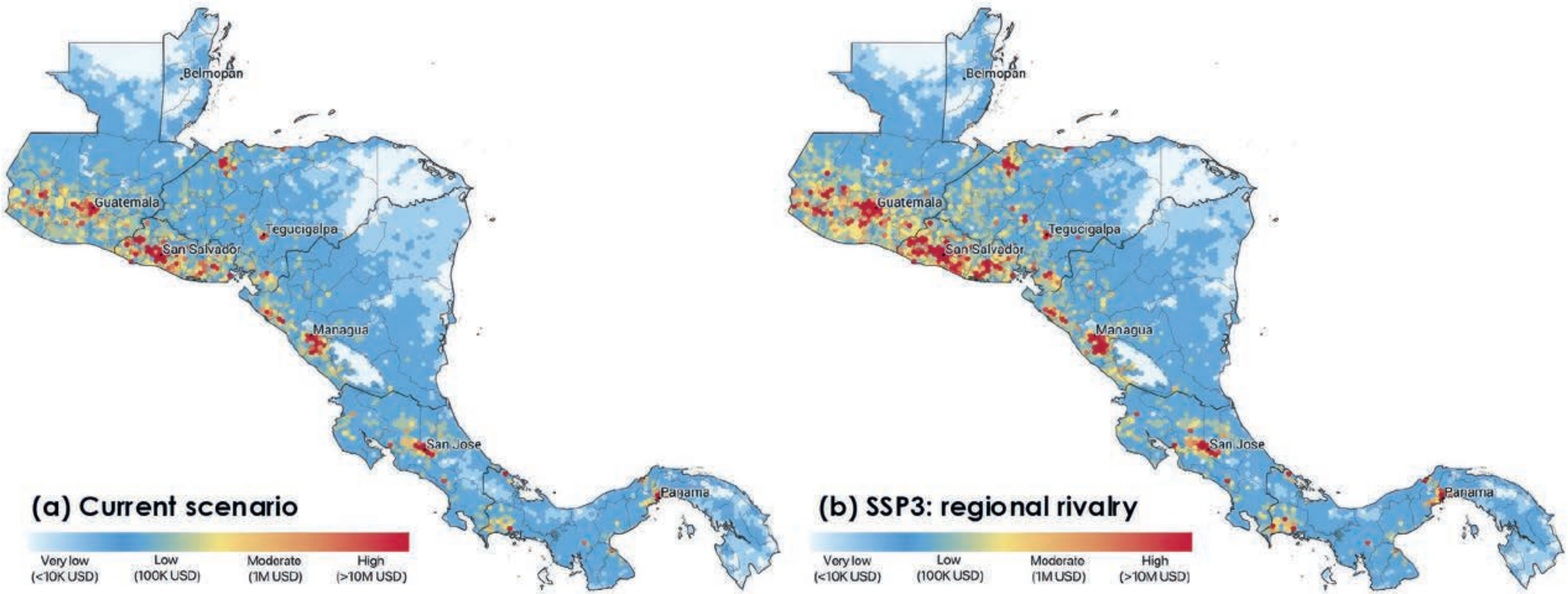
Zooming out across the whole of Central America, the same opportunities to reduce seismic risk are evident. Without increased investment in seismic resilience, earthquake-induced economic losses across Central America are projected to double by 2050, reaching up to $4.4 billion (Map 33). If code enforcement, building quality and urban planning remain inadequate, seismic risk is expected to rise significantly in the years to come, especially in El Salvador, Guatemala and Honduras. On the other hand, countries such as Panama and Costa Rica are expected to see lower increases in risk, as they have already begun enforcing building codes and have lower population growth projections.

If all countries across the region committed to ensuring that all new buildings complied with seismic safety standards, preliminary estimates suggest that around $1.1 billion in annual losses could be averted. Choosing now to build safer cities is not only cost-effective: it would also deliver immense benefits for future generations.

Map 33. **Earthquake-induced economic losses in Central America, current (a) and in 2050 (b)**



Source: GEM Foundation, 2025

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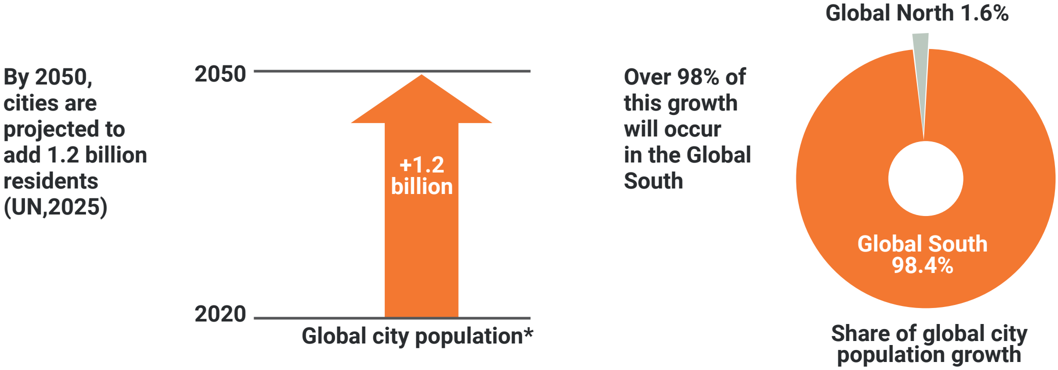
Importantly, the technological know-how to implement both retrofitting and code enforcement is already available: it must just be applied. Model-based probabilistic analysis, like the study above, is evolving quickly and offers powerful tools to reduce risk. Advanced analytics can already identify which building classes are most exposed to losses and evaluate to what extent their vulnerability would decrease if they were retrofitted, taking into account factors such as their construction material.[6] Such risk mapping, if used effectively, can serve as a blueprint for where to invest most effectively to reduce deaths and economic losses.

These findings have global implications, particularly against the backdrop of continued urbanization, as approximately 1.2 billion more people are expected to live in cities by 2050 compared to 2020. Over 98% of this growth will be in the Global South. (Figure 39).[7] [8] Ensuring these new buildings are safely situated and adequately constructed could save lives while safeguarding sustainable development, particularly in rapidly urbanizing locations.

Figure 39. Projected urban population growth by 2050



Source: After Tomorrow's Cities using data from the forthcoming UN World Urban Prospects, 2025

Improved risk analysis can support the development of innovative financial protection mechanisms, such as parametric insurance. As discussed in more detail in Chapter 6, probabilistic risk analysis is increasingly deployed to provide coverage to hard-to-insure assets often ineligible for traditional insurance policies. For example, Box 24 below describes how a ground-breaking parametric insurance policy provided Papua New Guinea's telecommunications infrastructure with vital coverage from earthquake risk.

Box 24. Protecting Papua New Guinea's telecommunications infrastructure against earthquake risk illustrates the benefits of innovative parametric insurance

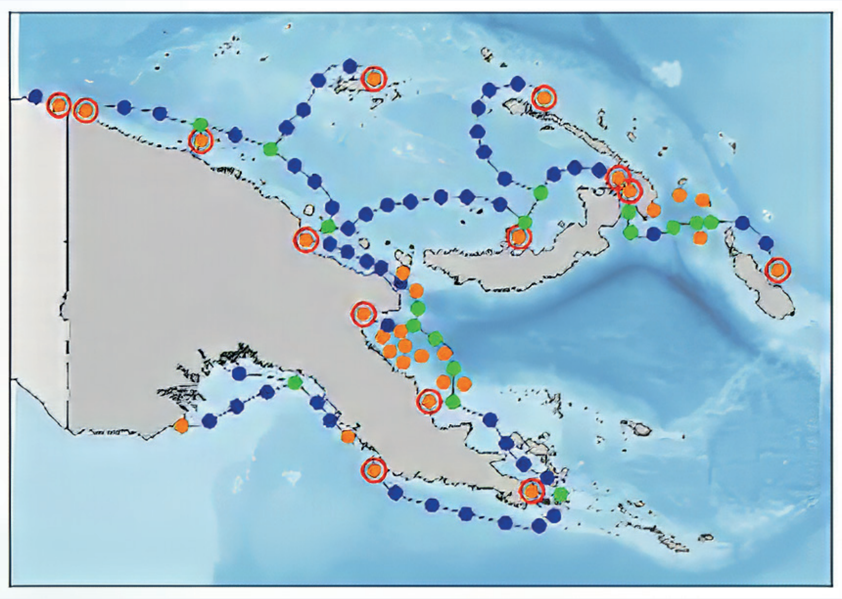
When disasters strike, the swift restoration of communication infrastructure is critical to recovering communities and businesses. However, traditional insurance is seldom available to protect infrastructure networks, leaving these vital assets heavily exposed. To overcome this issue, the parametric insurance model can provide a means to quickly access emergency funds in the wake of a disaster response, alongside other risk management approaches.

Following several cable breakages due to earthquakes in Papua New Guinea, the state-owned enterprise PNG Data Co., operating the national fibre optic transmission network, could not find a private sector insurer willing to offer financial protection. Indemnity insurance relies on post-disaster damage assessment to provide payouts to policyholders. Unfortunately, the submarine nature of fibre optic cables makes it impractical to assess the level of physical damage to the cable network and the associated costs of the repairs.

Without suitable coverage from the private sector, PNG Data Co. approached the Pacific Catastrophe Risk Insurance Company (PCRIC) to explore the possibility of creating a bespoke insurance product to meet its needs. After extensive research and analysis, PCRIC offered an innovative parametric insurance agreement that provided some protection for PNG Data Co. in the event of a catastrophic event. In this instance, the payout amount (a percentage of the total cover) under the policy is determined by the number of calculation sites that meet their respective ground-shaking trigger (Map 34).

This mechanism allows for the payout to be calculated very quickly after a qualifying event, as there is no damage assessment process. PCRIC can provide a payout within two weeks of a qualifying earthquake event. This coverage will help PNG Data Co. respond quickly to disasters, reducing their impact and boosting the country's overall disaster resilience.[9]

Map 34. **Parametric insurance calculation sites for ground-shaking triggers, Papua New Guinea**



Source: Pacific Catastrophe Risk Insurance Company (2023). "Case study on parametric insurance for disasters". In Global Shield against Climate Risks First In-Country Workshop in Fiji. https://www.globalshield.org/wp-content/uploads/2024/08/Global-Shield-Workshop-Fiji-PCRIC-case-study.pdf

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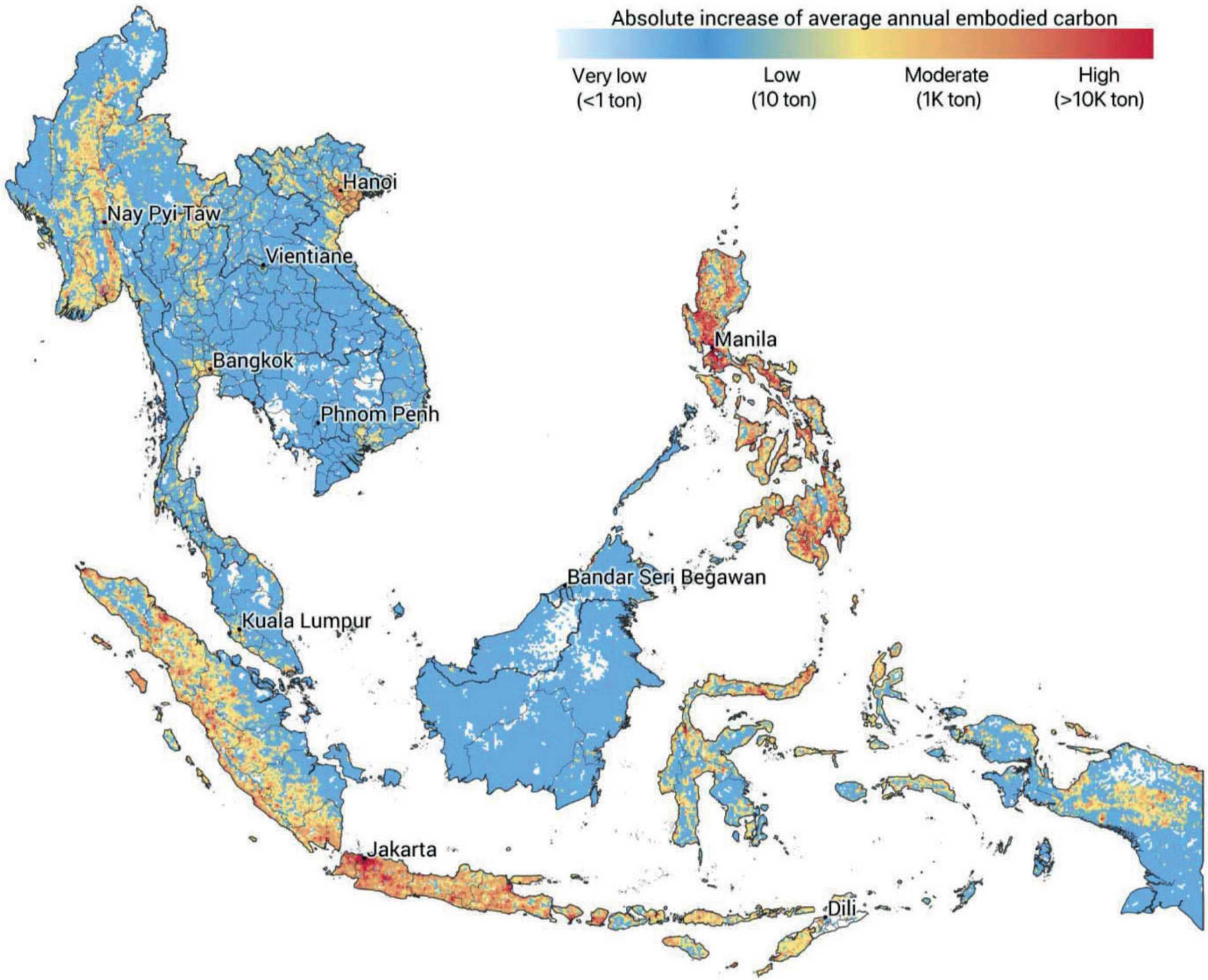
Note: discs colour-coded for site type; key sites have red disks.

There are also significant environmental costs associated with urbanization and earthquake risk that are often not fully acknowledged. These impacts are due to the considerable levels of "embodied carbon" involved in construction – in effect, the emissions that go into producing and transporting vital materials such as concrete, steel and glass – that is lost when a building is demolished. In Southeast Asia, for instance, one of the most seismically active parts of the planet, the expected average annual embodied carbon (AAEC) due to earthquake risk in the region is projected to double from current levels, reaching up to 10 million tonnes of CO_2 equivalent by 2050 (Map 35).

Map 35. **Absolute increase in average annual embodied carbon due to earthquake risk in Southeast Asia by 2050**



Source: GEM Foundation, 2025

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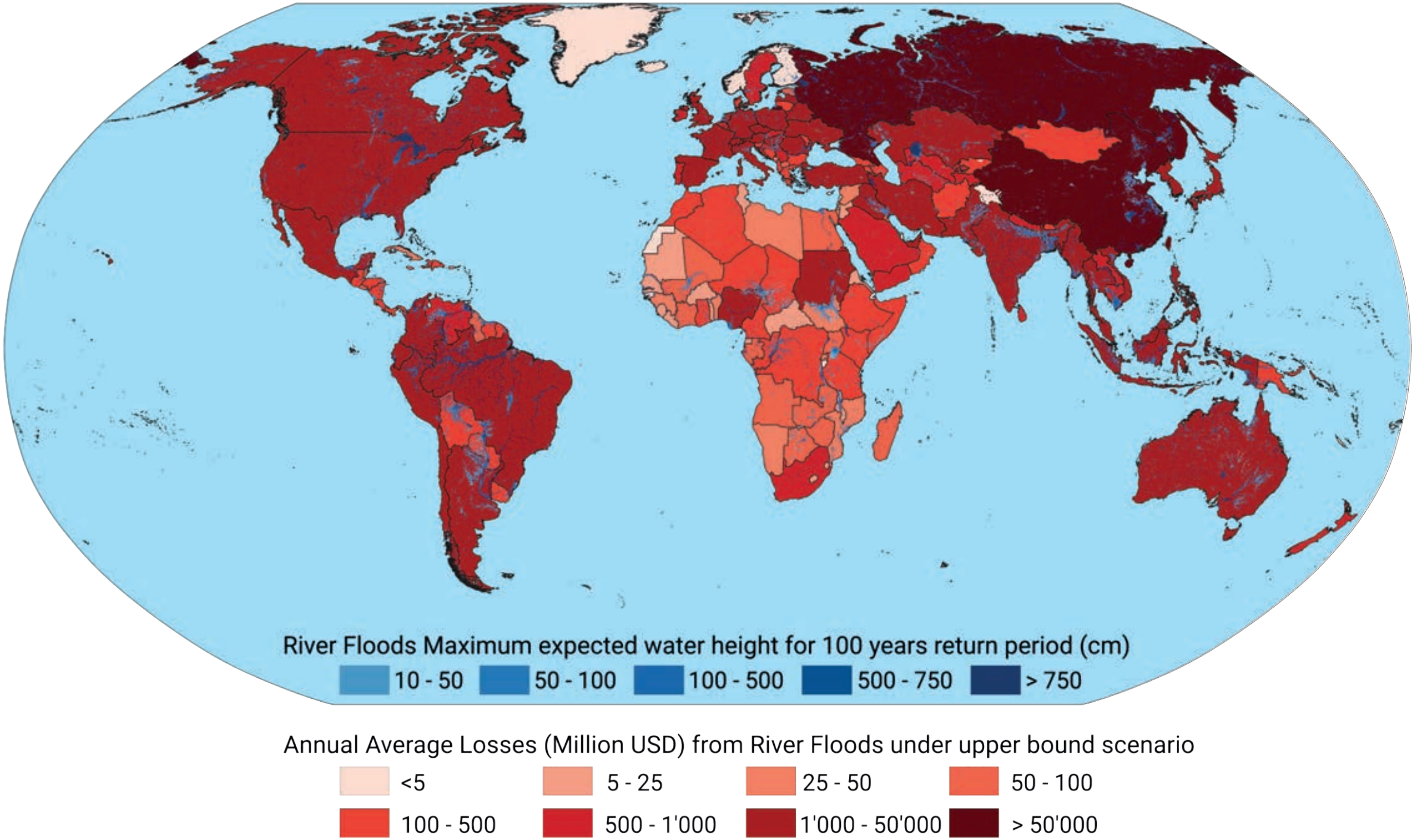
While countries like Thailand are expected to see a reduction in their exposure, as a large portion of new buildings are located in lower-risk areas, in Indonesia, new buildings are more likely to be concentrated in areas of high seismic risk. Given the carbon-intensive nature of construction and urban development, increasing seismic resilience can also positively impact the planet. The additional carbon cost of rebuilding is averted by preventing housing and infrastructure from being damaged or destroyed by an earthquake.

Future flood risk

The annual average losses associated with flooding total $388 billion globally. This is projected to rise considerably in the near future due to climate change. By 2050, models suggest that the average annual losses to infrastructure from riverine flooding will increase between 5% (under the low-emission RCP 2.6 climate scenario) and 13% (under the high-emission RCP8.5 scenario), reaching $407–439 billion in annual losses (Map 36).[10]

Not all regions will see the same flood hazard trends under these projections. While some regions may get drier and affected by drought rather than flooding (such as Southern Europe, Australia and New Zealand, Central America or Southern Africa). Other regions may experience higher average annual losses as a result of more frequent and intense flooding: for example, Western Asia (+60%), Melanesia (+44%), Eastern Africa (+42%), Middle Africa (+31%), Eastern Europe (+28%), Southern Asia (+23%), Northern Africa (+19%) or Central Asia (+17%).

Map 36. Projected average annual economic losses to infrastructure from riverine flooding under RCP 2.6 and RCP 8.5 scenarios up to 2050



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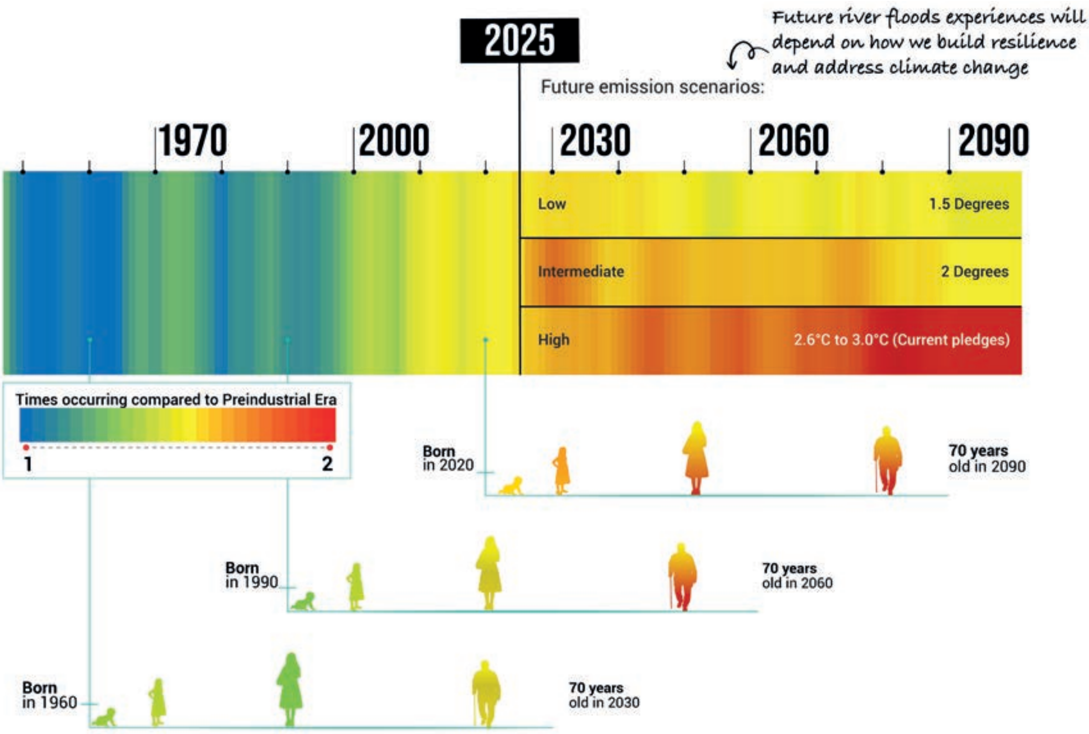
Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.

A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

Source: Data: CDRI, 2023:
Cartography: UNEP/GRID-Geneva, 2024.

Translating this analysis to an individual lifetime illustrates this future even more starkly. As Figure 40 shows, for someone born into the climate that existed in 1990, the probability of experiencing a 1-in-100-year flood event during an average 70-year lifespan was about three in five (63%). For someone born in 2025, on the other hand, that probability would rise to nearly nine in ten (86%), meaning an increase of roughly 36% compared to those born in 1990. This increase is driven by the fact that floods that were considered "once in a century" in the pre-industrial climate (1850–1900) were already happening about 30% more often in 1990 and are projected to occur over two and a half times as frequently by 2025 under current climate pledges (corresponding to an estimated warming of approximately 2.6–3.0°C by 2100).[11] In lower-emission scenarios associated with a rise of 1.5–2.0°C, as the graphic shows, the increase in risk would be less pronounced.

Figure 40. Projected lifetime probability of experiencing a 1-in-100-year flood event, by year of birth



Source: UNDRR adaptation of data from Thiery et al. (2021)[12]

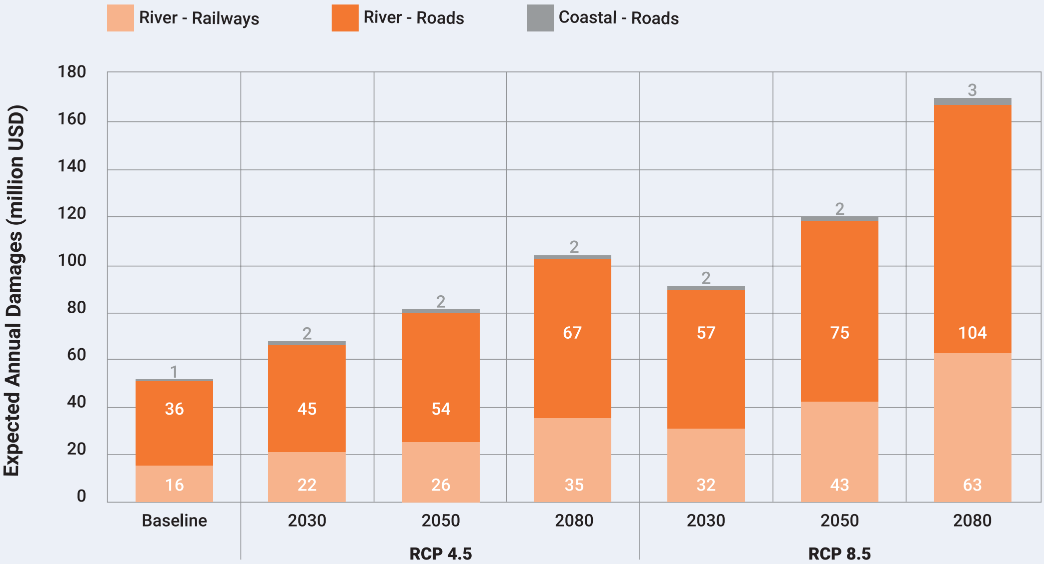
In any of the pathways above, the rationale for investing in protecting people and assets from more frequent and intense flood events is clear. For example, Box 25 showcases how East African governments are taking action to apply future-oriented risk analysis to assess and reduce risk to regional transport networks, achieving cost savings from direct and potential cascading impacts.

Box 25. Climate risk and adaptation for transport networks in East Africa

Flooding already poses a significant threat across East Africa, a situation that is only projected to intensify in the coming years due to the severity of climate change in the region. One of the areas particularly impacted by these impacts is the transport sector, with roads, bridges and other costly infrastructure exposed to significant risks. There is a pressing need to invest in resilience building, but given the scale of the challenge, identifying where and how to prioritize these interventions is key.

With this in mind, an assessment of transportation networks in Kenya, Tanzania, Uganda and Zambia identified existing vulnerabilities and modelled future disaster impacts on supply chains and trade flows.[13] Figure 41 depicts the expected annual damages from river and coastal flooding in baseline conditions and for 2030, 2050 and 2080 under future climate conditions RCP4.5 (representing a modest mitigation scenario) and RCP8.5 (a high-emissions scenario). What is immediately evident is how the cost of flooding in the region's transport infrastructure will likely increase dramatically if no adaptive measures are implemented.

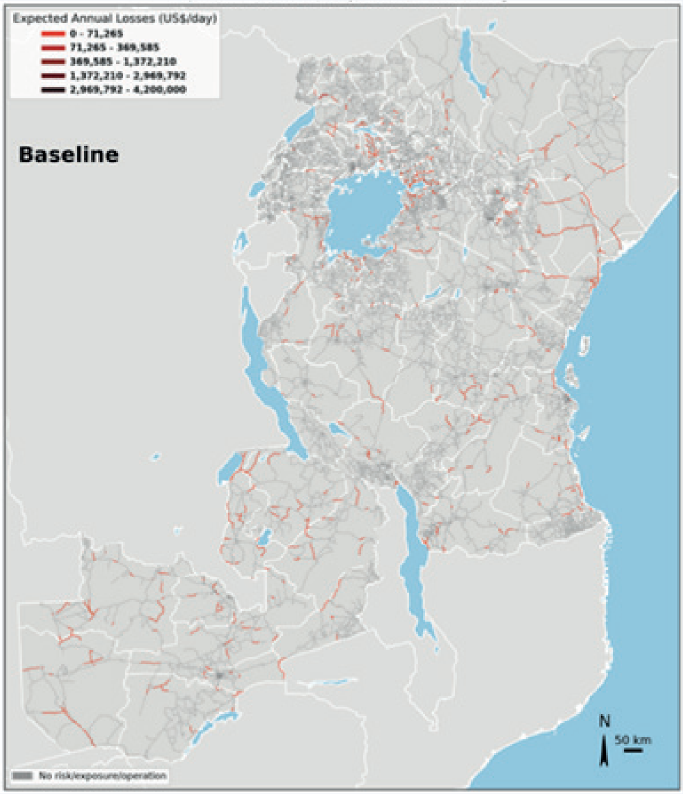
Figure 41. Expected annual damages, in million USD, from river and coastal flooding of roads and railways in baseline conditions and for 2030, 2050 and 2080, under RCP4.5 and RCP 8.5

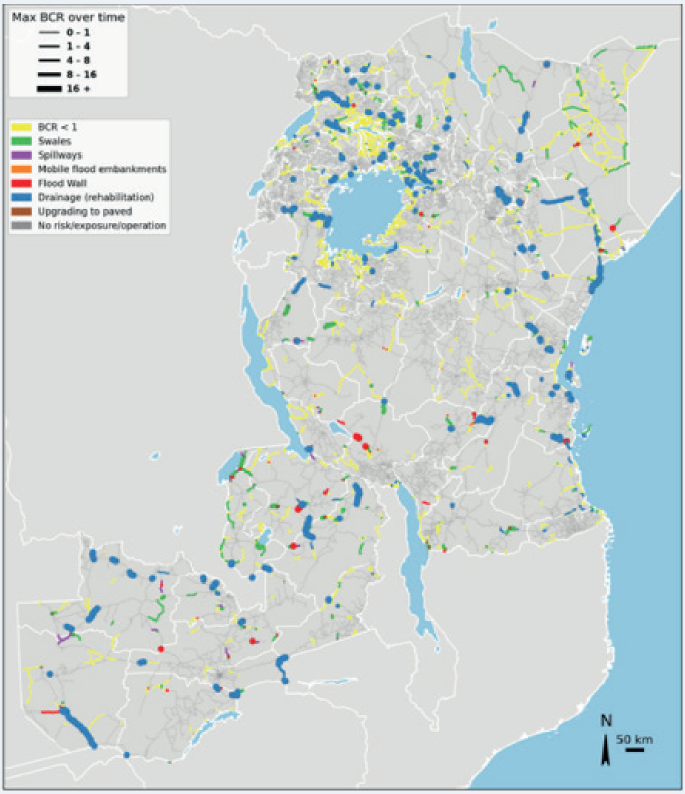


Source: Jaramillo, Diana and Pant, Raghav 2023)

The research also explored several adaptation options for strengthening the resilience of road and rail links to flooding, comparing the costs of implementation with the total value of losses averted as a result. Respectively maps 37a and 37b show the expected annual economic losses from river flooding to roads under baseline conditions and the benefit-cost ratios (BCR) if adaptation options are implemented. The results showed a compelling case for investing in the climate adaptation of several assets, with the benefits of avoiding climate risks far outweighing the investments needed until 2080.

Maps 37a & 37b. Expected annual economic losses to roads from river flooding under baseline conditions, $/day (a); benefit-cost ratios (BCR) of optimal adaptation options (b)





Source: Hickford et Al (2023). “Decision support systems for resilient strategic transport networks in low-income countries”. Reference no HVT/043. University of Oxford.

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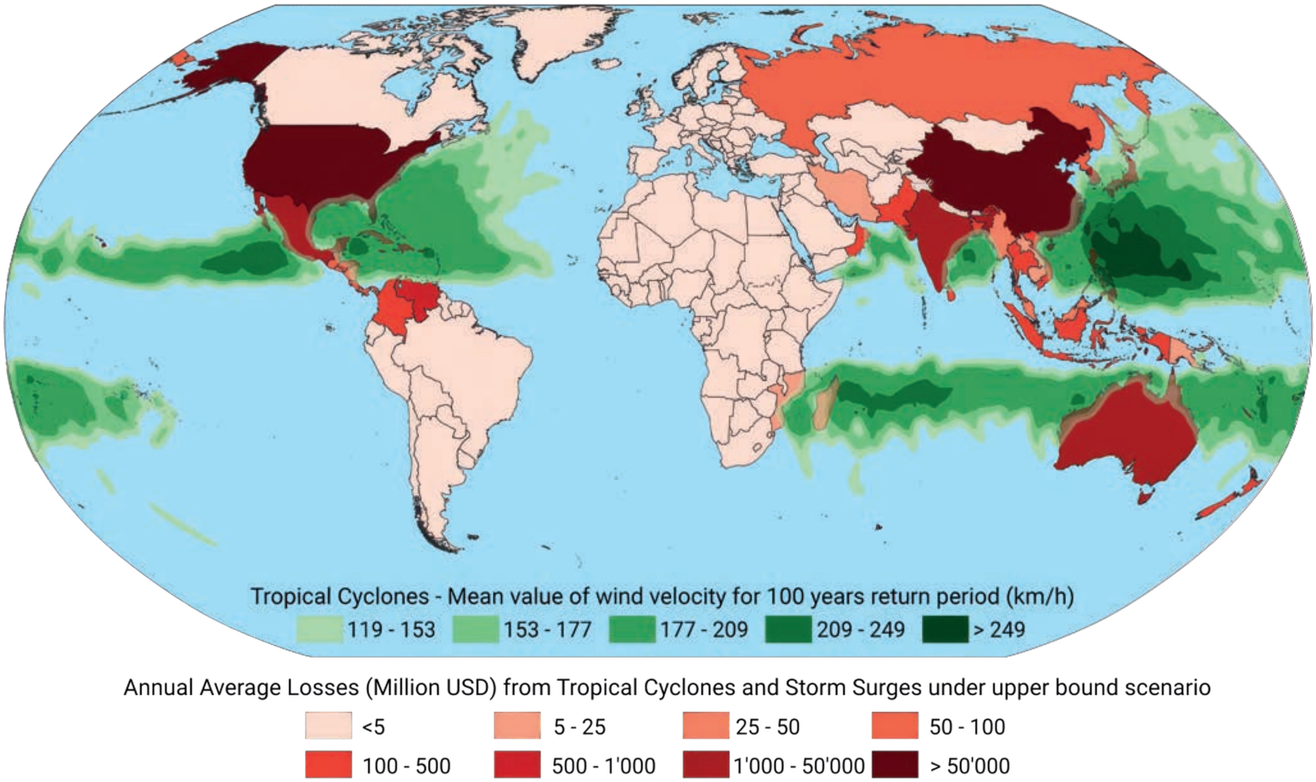
Future storms and tropical cyclone risk

The IPCC clarifies that the severity of storms such as tropical cyclones will increase with warmer sea temperatures.[14] Tropical cyclones are also expected to move poleward, given that new regions will likely see their ocean temperatures reach 26°C (the minimum threshold for cyclones to occur).[15] This means that areas not previously susceptible must learn how to prepare.

The already immense economic impacts of storms are expected to worsen. The losses generated by tropical cyclones (Map 38) generate storm surges, precipitation, flooding and winds that together generate average annual losses of $112 billion. In the current climate, a 1-in-100-year tropical cyclone would affect between 65 and 80 million people.[16] By 2050, in a high-emission climate change scenario (RCP8.5), these losses could increase by 35.6% to $152 billion annually. In absolute values, the main countries affected would be the United States of America, Japan and China. However, in relative terms, low-income countries such as small island developing states (SIDS) may suffer far greater impacts and have fewer resources to prevent disasters and support recovery.

Map 38. Projected average annual economic losses to infrastructure from tropical cyclones under RCP 2.6 and RCP8.5 climate scenarios, 2050



Source: Data: CDRI, 2023:
Cartography: UNEP/GRID-Geneva, 2024.

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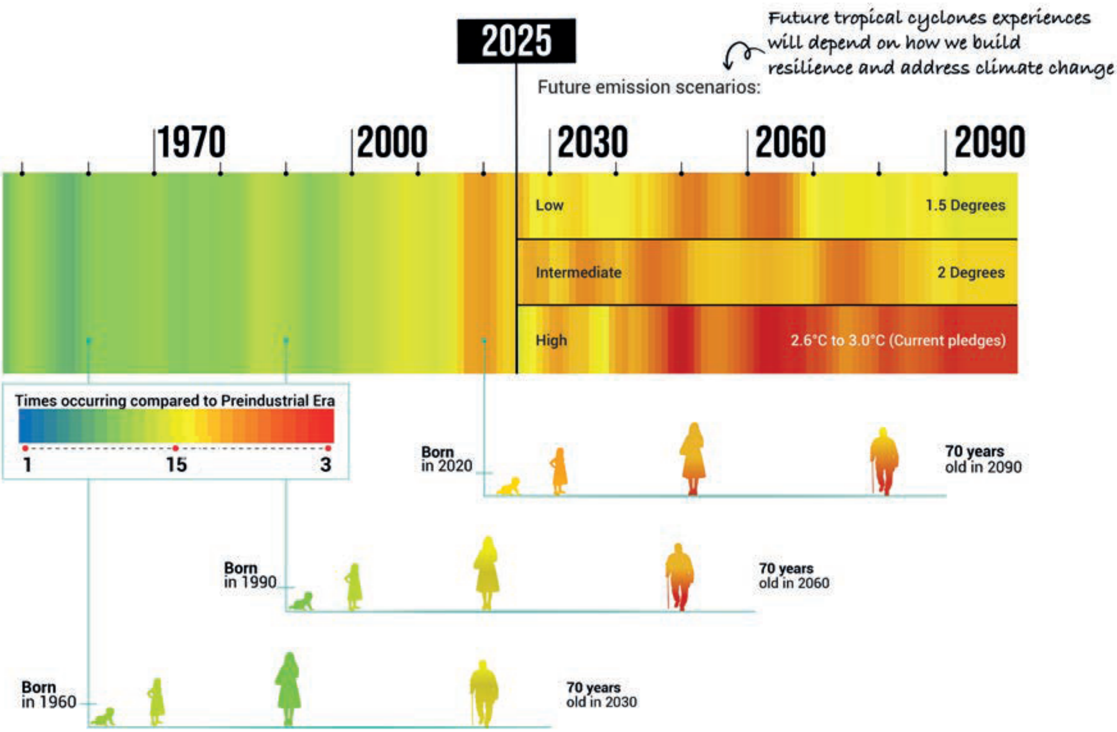
In human terms, this means that someone born into the climate that existed in 1990 would have a probability of experiencing a 1-in-100-year tropical cyclone event during an average 70-year lifespan of about four in five (79%). For someone born in 2025, on the other hand, that probability would rise to nearly nine in ten (86%), an increase of roughly 9% compared to those born in 1990.

This increase is driven by the fact that tropical cyclones that were considered "once in a century" in the pre-industrial climate (1850–1900) are now happening twice as often in 1990 and will occur nearly two and a half times as often by 2025 under current climate pledges (corresponding to an estimated warming of approximately 2.6°C–3.0°C by 2100) (Figure 42).

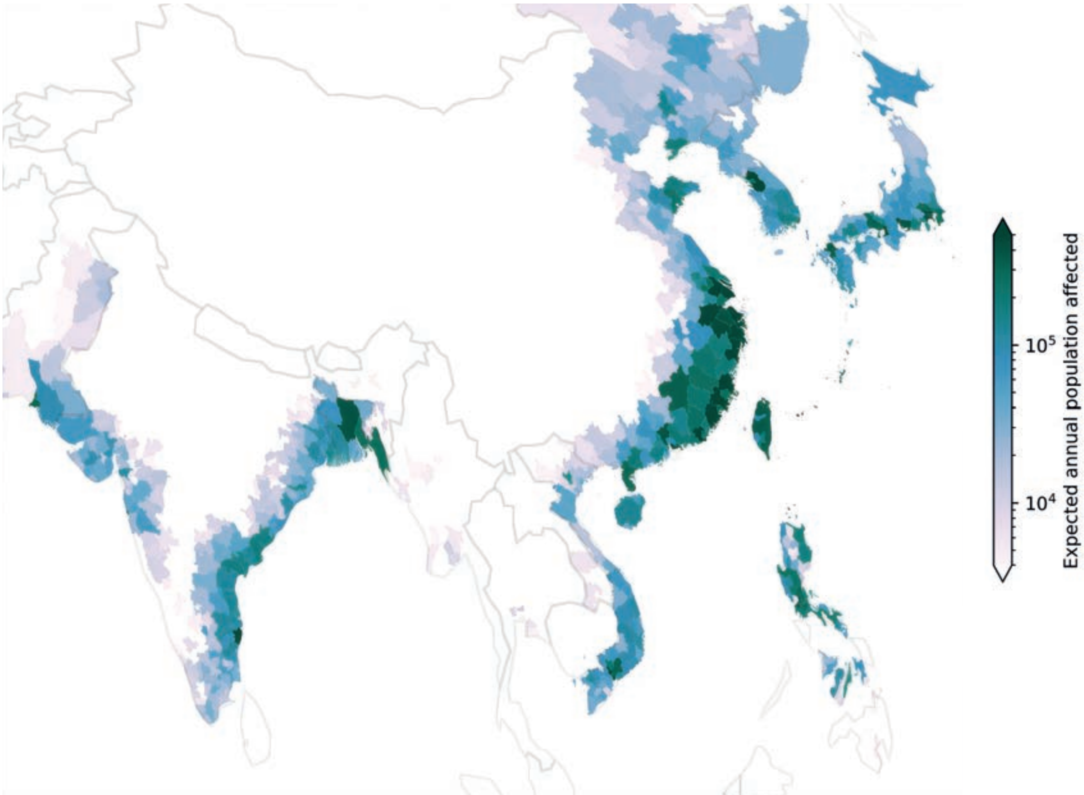
Figure 42. **Projected lifetime probability of experiencing a 1-in-100-year tropical cyclone event**



Source: UNDRR adaptation of data from Thiery et al. (2021)[17]

Impacts can be significant during our lifetimes on assets such as power networks. Map 39 shows how tropical cyclone risk may evolve in Asia in a high-emission (RCP8.5) scenario and how this may impact cyclone-induced power outages. Looking ahead, even South Korea and Japan, which already endure notable impacts, are projected to experience substantial increases in the proportion of their populations affected under future conditions, unless resilient investment is stepped up.

Map 39. Expected increase in annual population in Asia affected by typhoon-induced power outages by 2050 under a high emission (RCP8.5) scenario



Source: Hall, J., Thomas, F., Mo, Y., Rui, J., Russell, T., Robertson, M., Verschuur, J., & Pant, R. (2024). Tropical cyclone risk to global electricity supply. Square Research. https://doi.org/10.21203/rs.3.rs-4650238/v1

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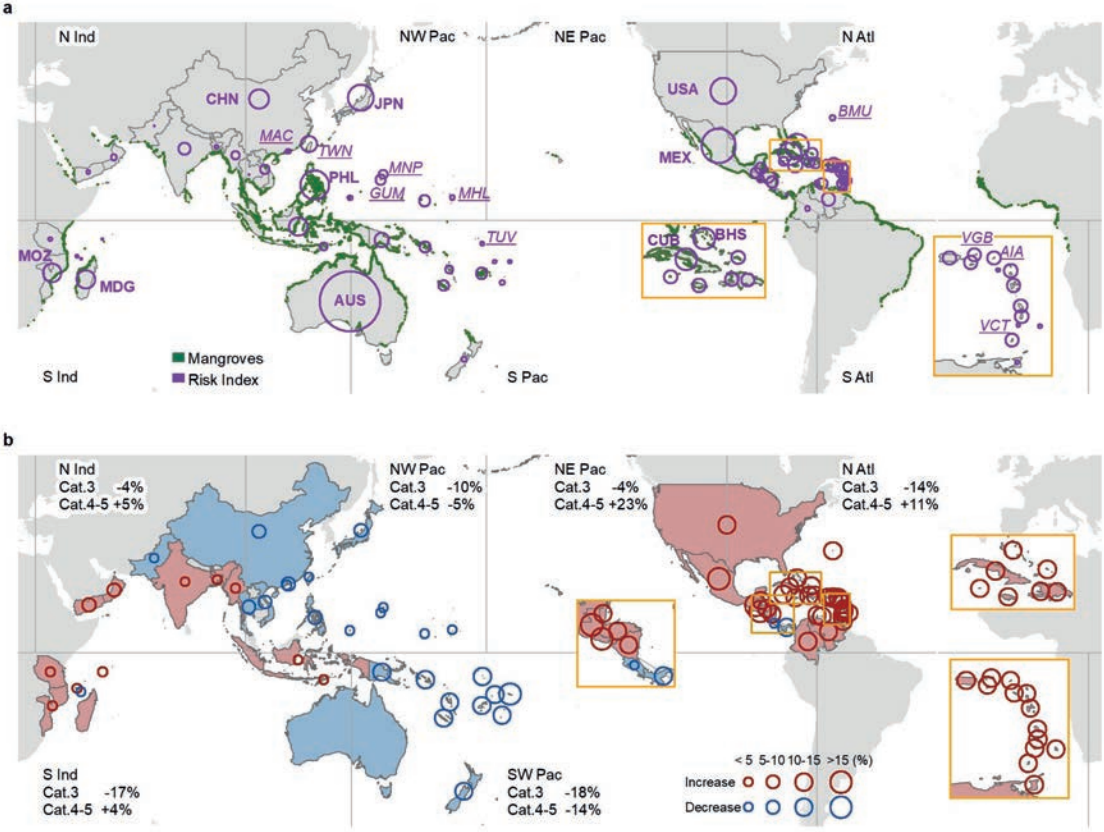
Some countries are already taking notice. For example, in the eastern coastal state of Odisha, India,[18] in 2019, Cyclone Fani caused approximately US$1.2 billion in damage to power infrastructure.[19] The impacts highlighted the need for more disaster and climate-resistant infrastructure.[16] Based on a three-phase study of risk to Odisha's power systems, the government began prioritizing upgraded investments to protect key systems to be fit for the climate future.[20]

The impacts of increased storms also undermine fragile ecosystems like mangroves and coral reefs. For example, 97% of the risk of substantial damage to mangroves is due to storms that develop into major (category 3–5) tropical cyclones. These destroy natural buffers such as mangroves, and protect people and their assets from storm surges and the full force of winds and floods. The current exposure of mangroves to tropical cyclones worldwide is likely to increase significantly by 2050 (Map 40). At the country level, the risk is widely distributed across the globe, but there are clear risk hotspots in mangroves bordering the Gulf/Caribbean, the South Indian Ocean and the Northwest Pacific. In addition to the well-recognized risks in the Gulf/Caribbean region and Oceania,[21] the Northwest Pacific hosts 3 of the 10 areas with the highest total risk (China, Japan and the Philippines) and 4 of the 10 with the highest risk per unit area of mangroves (including Guam, the Marshall Islands and the Northern Mariana Islands).[22]

Map 40. Mangroves at risk from tropical cyclones, current and projected (2050)



Source: Mo, Yu, Marc Simard, and Jim W Hall. 2023. "Tropical Cyclone Risk to Global Mangrove Ecosystems: Potential Future Regional Shifts." Frontiers in Ecology and the Environment 21 (6): 269–74. https://doi.org/10.1002/fee.2650.

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However, building resilience in advance can ensure that natural buffers are in place, benefiting people and the planet. Box 26, for instance, shows how investing in resilience through an innovative local-level reef insurance project is helping communities better cope with shocks and ensuring that a coral reef in Mesoamerica continues to flourish despite the growing threat of cyclones.

Box 26. Protecting the Mesoamerican Reef through parametric insurance

The Mesoamerican Reef is the largest reef in the Atlantic Ocean, stretching over 1,000 kilometres along the coast of Mexico, Belize, Guatemala and Honduras. This vast expanse supports seagrasses, coral reefs and more than 500 species of fish, including the endangered whale shark, manatees and turtles. The reef also protects the safety and livelihoods of more than 2 million people and delivers $4.5 billion every year to key blue economy sectors. However, despite these many benefits, this unique ecosystem is under threat.

The Reef Rescue Initiative, one of the Mesoamerican Reef Fund projects, was established to provide much-needed protection. In partnership with government bodies and local organizations, the programme has created a strong framework for improved reef management and resilience through emergency preparedness protocols, training and capacity building. In addition, it has developed an innovative framework for financing post-disaster restoration of the reef through two main components. These are the contingency reserves of an emergency fund for use in the wake of a major disaster, and a tailored Mesoamerican Reef Fund Insurance Programme.

The latter scales the funds available through the emergency fund in the wake of a major hurricane, leveraging risk markets to pre-arrange additional financing for the response. The programme uses parametric insurance to support a timely and locally-led reef response by deploying a dynamic model that correlates hurricane intensity with reef damage. If a hurricane reaches a pre-agreed wind speed threshold within the covered area, a payout is made to the fund. These funds are then directed to “reef guardians” from the affected communities who survey the damage and repair the broken corals.

Launched in May 2021, the programme initially provided insurance coverage to four key sites across the Mesoamerican Reef and has since expanded to cover 10 reef sites. Hurricane Lisa in 2022 triggered the first payout of the programme, totalling $175,000, to fund reef response activities across the Turneffe Atoll National Marine Reserve in Belize.

Scenics from the coral reefs of the mesoamerican barrier. Mayan Riviera, Mexican Caribbean.

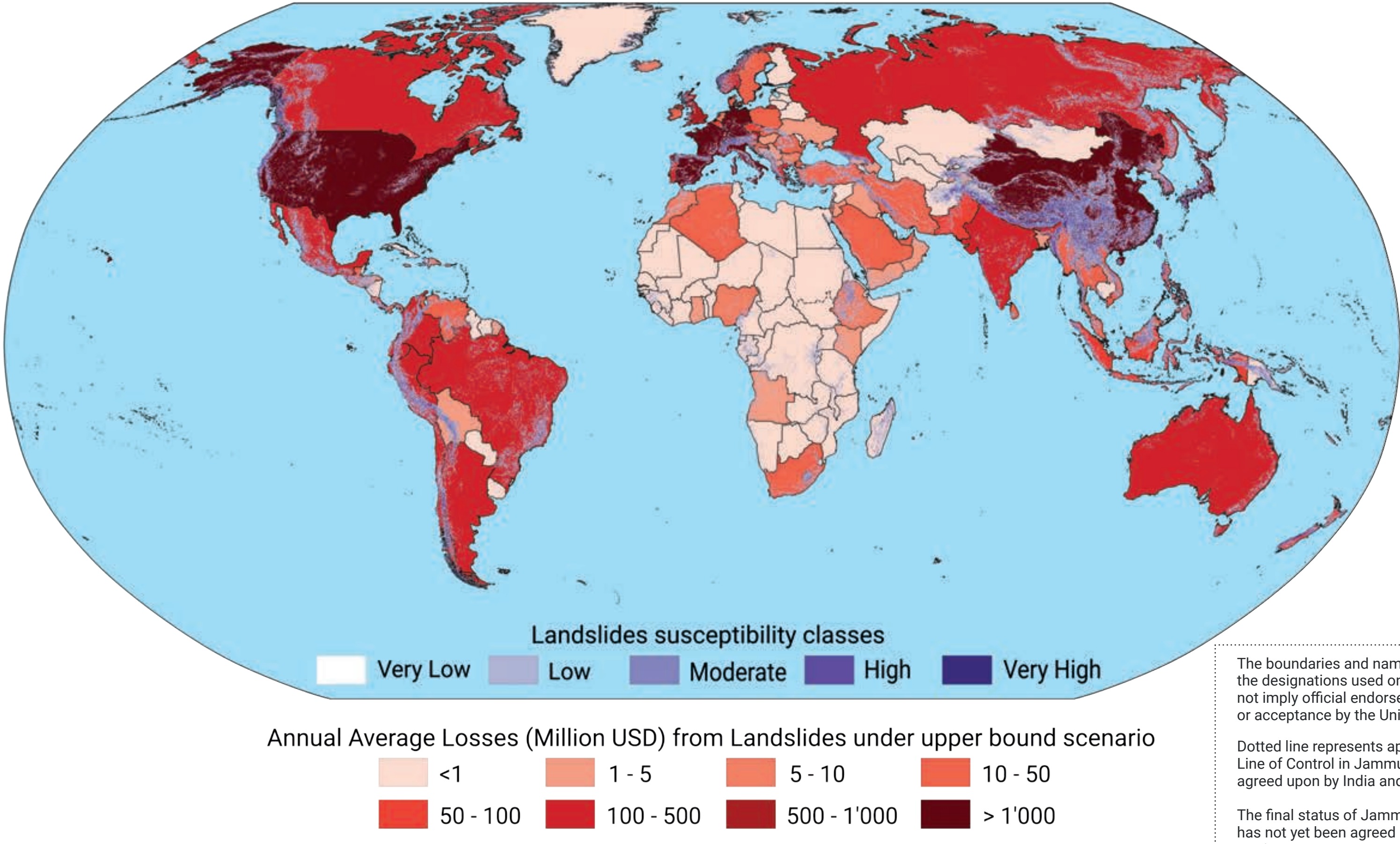
Credit: Shutterstock, Leonardo Gonzalez

Compounding landslide risk

In addition to damaging marine and coastal ecosystems, climate-related hazards such as increased flooding and rainfall are also escalating landslide risk in mountainous areas. Landslides caused approximately $34.2 billion in annual economic losses between 2000 and 2023.[23] Projections suggest that, under moderate climate change scenarios, the annual losses associated with landslide-related risks could reach $37 billion by 2050.[24]

Though models suggest that the total number of events will not change significantly, the loss locations may change (Map 41). While some regions, like Polynesia (+68%), Eastern Africa (+34%), Middle Africa (+32%), Southern Asia (+30%), Western Africa (+29%) and Central America (+22%), will see a significant increase in their average annual economic losses. Other regions will see a fall in their average annual losses, for example, Micronesia (-47%), North America (-21%), Central Asia (-21%), Northern Europe (-20%) and Southern Africa (-17%).

Map 38. Projected average annual economic losses to infrastructure from tropical cyclones under RCP 2.6 and RCP8.5 climate scenarios, 2050



Source: Data: CDRI, 2023:
Cartography: UNEP/GRID-Geneva, 2024.

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Landslides can be avoided through environmental management. For example, while deforestation can increase risk, vegetation or other engineering methods can help stabilize the slopes by sheltering the soil from rain. In the aftermath of landslides, emergency interventions are vital in minimizing the impact and preventing further movement.[25]

For instance, in April 2022, a subtropical depression along the coastal region of eThekwini, KwaZulu-Natal in South Africa triggered intense precipitation, averaging 200–450 millimetres over a five-day period. The cyclone impact resulted in the deadliest landslides in years and unprecedented infrastructural damage. However, prompt action helped prevent more landslides: after factoring in the site-specific geologic conditions, ease of installation, long-term performance and cost, embankments were reinforced with ground anchors that prevented further damage.

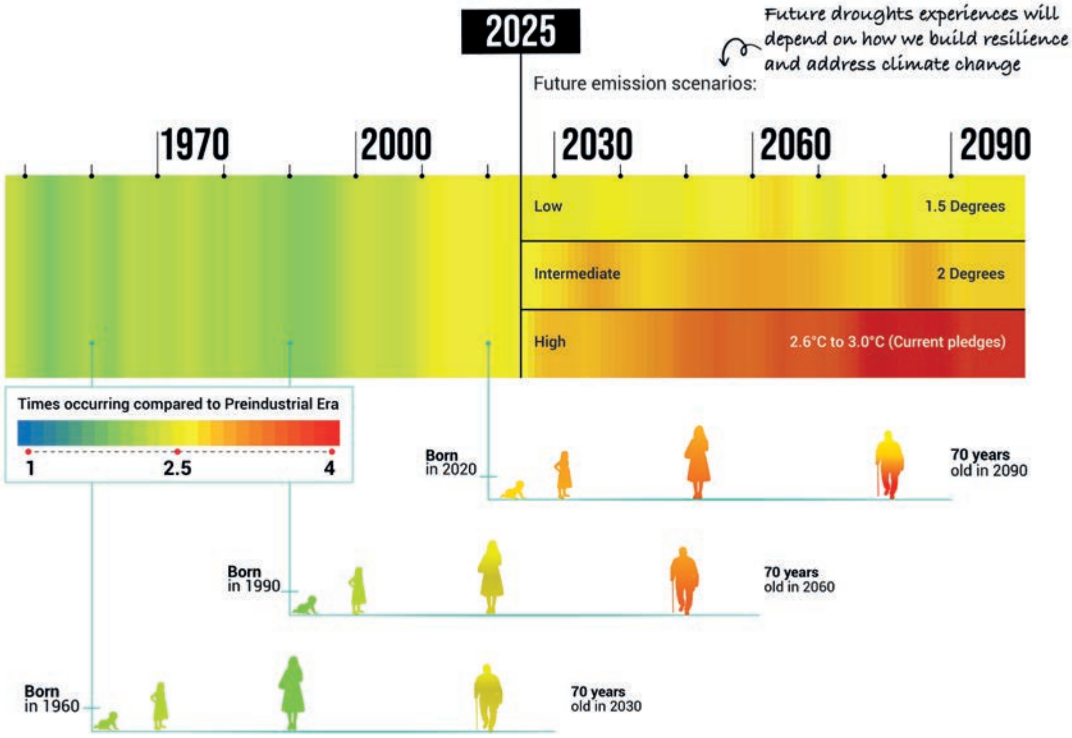
Future drought risk

Drought risk continues to intensify in many parts of the world, driven by climate change, water scarcity, poor resource management and unsustainable land use.[26] According to forecasts, by 2050, droughts may affect over three-quarters of the world's population.[27] Human activity contributes to the increasing drought frequency and directly impacts food security and human wellbeing. Assessing the current economic impact of drought, let alone its potential effects in future, is not easy given that so many of its impacts are indirect, and even the start and end dates of drought events are not always clear. However, drought-induced losses are estimated to cost approximately $307 billion annually, representing 15% of global disaster-related economic losses, and are responsible for 86% of livestock deaths.[28]

Nevertheless, promising work is underway to improve risk analysis, using advanced modelling and the deployment of machine learning. The 2024 Drought Resilience +10 Conference (DR+10) affirmed joint efforts to strengthen drought resilience through integrated drought management and other proven approaches. However, more is needed to enhance international collaboration around the drivers of globally networked risks, for instance, the trade and food security impacts from droughts in different parts of the world, across regions, nations, sectors and communities.[29]

As with the other hazards described above, it is useful to consider how these projected changes will impact an individual's lifespan. Figure 43 shows that someone born into the climate that existed in 1990 had the probability of experiencing a 1-in-100-year drought event during an average 70-year lifespan of about three in four (76%). That probability rises to nearly nine in ten (89%) for someone born in 2025. This increase is driven by the fact that droughts that were considered "once in a century" in the pre-industrial climate (1850–1900) are now happening nearly twice as often in 1990 and will occur almost three times as often by 2025 under current climate pledges (corresponding to a warming of 2.6–3.0°C of global warming).

Figure 43. **Projected lifetime probability of experiencing a 1-in-100-year drought event**

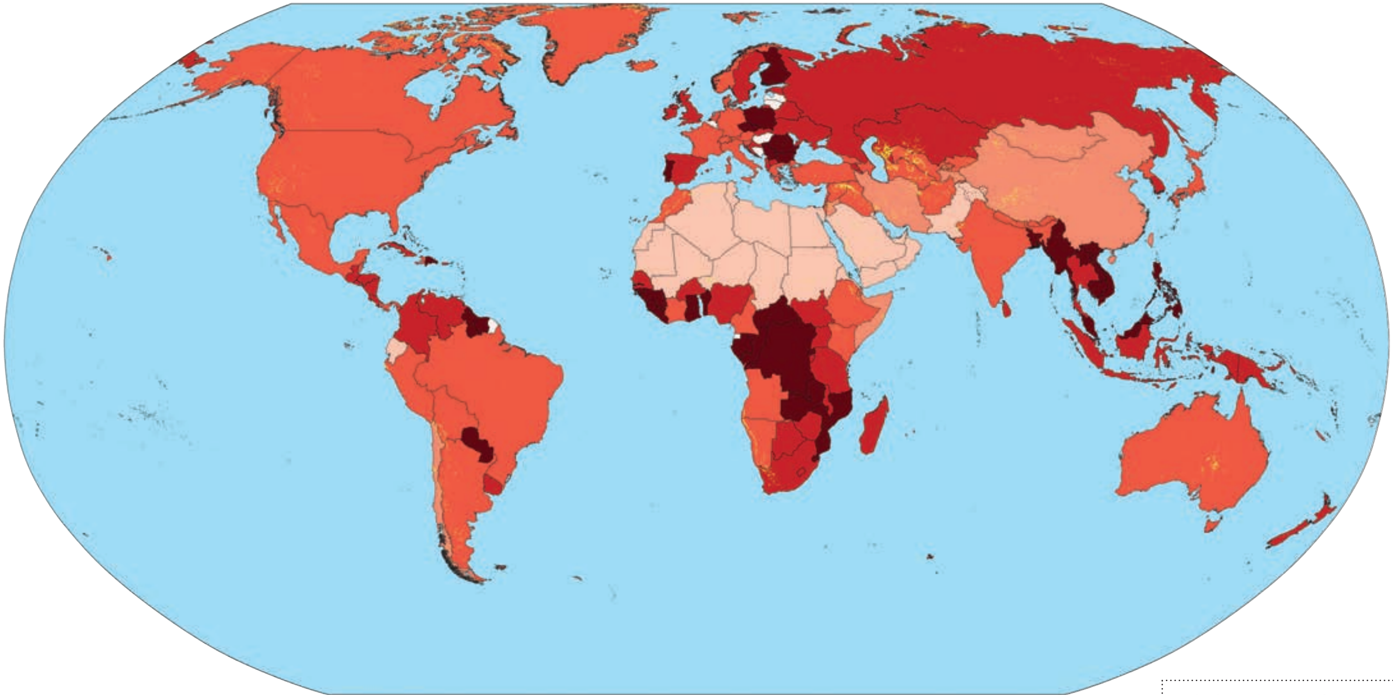


Source: UNDRR, adapting data from Thiery et al. (2021)[30]

Desertification risk in the future

The 21st century will likely continue to see significant changes in global land use. Drought impacts can be intensified by unsustainable land use, and vice versa. Desertification, the process whereby fertile land becomes desert, is already a significant environmental risk, degrading ecosystems, reducing biodiversity and lowering agricultural productivity.[31] Preventing it is crucial to maintaining the health of these ecosystems and securing the livelihoods of communities dependent on the land. However, as Map 42 shows, desertification has accelerated worldwide in the past two decades, with some of the most pronounced hotspots concentrated in sub-Saharan Africa and Southeast Asia. Understanding the differences in how desertification affects natural vegetation and cropland is essential for developing effective strategies to combat its impacts, including the threat it poses to global food security.[32]

Map 42. Global desertification rates, 2003–2022



Desertification rate for 2003 - 2022 in percentage of total desert area

0 | 0 - 2.5 | 2.5 - 5 | 5 - 25 | 25 - 50 | 50 - 100

Non Desert to Desert Surfaces

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Data: CDRI, 2023:
Cartography: UNEP/GRID-Geneva, 2024

Significant future losses may occur in soil degradation, which may be accelerated during periods of drought unless remedial action is taken. Globally, up to 40% of land area is now considered degraded,[33] with an additional 100 million hectares of healthy land degraded yearly.[34] The most recent estimates put the cost of desertification and land degradation at $570 billion globally.[35] Looking forward, over 90% of the land is at risk of becoming degraded by 2050.[36] Business-as-usual scenarios predict that an additional 300 million hectares of forests and other natural ecosystems could be destroyed between 2015 and 2050, primarily due to natural land being converted to cropland,[37] with grasslands particularly vulnerable.[38]

Because 95% of the human food supply comes from the soil, sustainable soil management is critical for ensuring a sustainable and food-secure world for future generations. Soil erosion occurs naturally under all climatic conditions and on all continents, but it is significantly increased and accelerated (up to 1,000 times[39]) by unsustainable human activities such as intensive agriculture, deforestation, overgrazing and improper land use changes. At present, soil erosion rates are much higher than soil formation rates. This matters for current and future generations because soil is a finite resource, meaning its loss and degradation are irreversible within a human lifespan.[40] It can take up to 1,000 years to produce just 2–3 centimetres of soil.[41] Effective and sustainable soil management is therefore a key element in preventing water scarcity from developing into destructive drought.

Desertification is a significant environmental risk with severe consequences for both natural ecosystems and agricultural lands. It leads to natural vegetation and cropland degradation, reducing biodiversity and agricultural productivity.[42] Preventing desertification is therefore crucial to maintaining the health of these ecosystems and securing the livelihoods of communities dependent on the land, and understanding the differences in how desertification affects natural vegetation and cropland is essential for developing effective strategies to combat this threat and mitigate its economic consequences.[43]

Future extreme heat

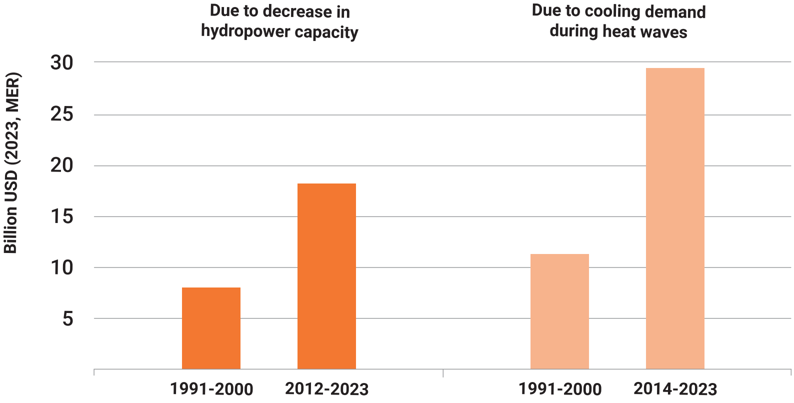
As discussed in Part 1 in more detail, extreme heat is already associated with poorer health outcomes, falling labour productivity, and increasing fatalities and disaster costs. As heat stress events intensify, these impacts stand to increase volatility considerably across a range of sectors (see Box 27 on Oman). As temperatures continue to rise, the impacts of extreme heat are projected to be wide-ranging, disrupting livelihoods in urban and rural areas. According to the Intergovernmental Panel on Climate Change (IPCC) predictions, with 1.5°C of warming, 67 cities will experience over 150 days a year of temperatures greater than 35°C – a figure rising to 197 cities with 3°C warming.[44]

Indeed, the agricultural sector, where over 940 million people, including many of the world's poorest citizens, earn their livelihoods, is already disrupted by the effects of extreme heat as higher temperatures push workers to the limits of their endurance and threaten crops with drought. Without resilience building, the result is lost labour, smaller harvests and higher consumer prices.[45] For example, during the 2012 heatwave in the United States, maize yields dropped by 13%, resulting in a sharp increase in global corn prices because the country supplies 40% of global production. In the short term, the food price volatility resulting from these weather events puts low-income countries, particularly those with high crop import dependency ratios, at risk of food insecurity.[46] In some areas of India, for example, the effects of shifting weather conditions on agriculture and other sectors are projected to result in a 9% fall in living standards by 2050 if no action is taken, affecting hundreds of millions of people and reversing vital progress in terms of poverty reduction.[47]

Extreme heat events also impact the energy sector by increasing demand while decreasing supply. In

2023, approximately 800 terawatt-hours (TWh) of electricity were used for cooling during extreme heat events, compared to less than 300 TWh in the 1990s, with the associated costs increasing from just over $10 billion annually in the 1990s to nearly $30 billion a year in the last decade.[48] Extreme heat also reduces the effective capacity of power plants, increasing transmission losses, increasing energy demand for cooling and decreasing energy demand for heating. In addition, in many regions, hydropower output has been falling due to higher temperatures and other climate change impacts. These factors have reduced hydropower capacity by around 330 TWh in power generation annually and driven up the energy production costs (Figure 44).[49]

Figure 44. **Global annual costs of climate impacts to hydropower in a heating climate**

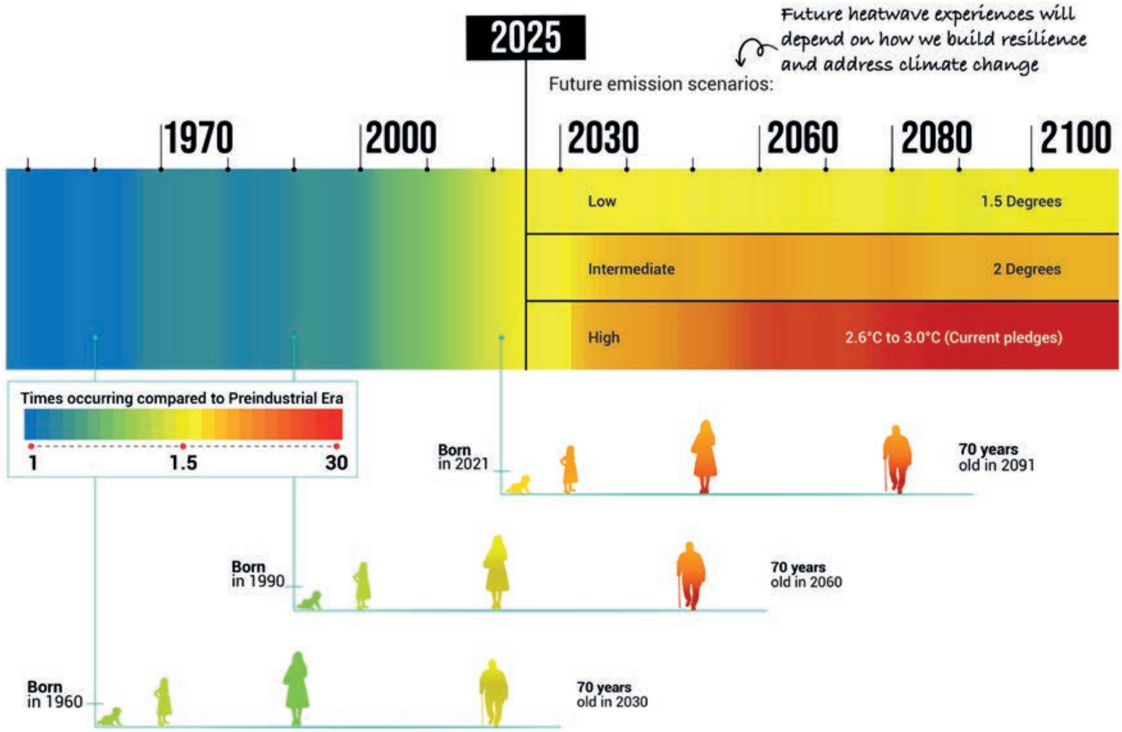


Annual climate-related costs from lower hydropower output and higher cooling demand have already risen by around USD 30 billion since the 1990s

Source: IEA World Energy Outlook (2024)

Extreme heat has become a much more pronounced phenomenon in recent decades, illustrated by the fact that heatwaves that were considered "once in a century" in the pre-industrial climate (1850–1900) were already happening more than four times as often in 1990 and will occur over 18 times as frequently by 2025 under current climate pledges (Figure 45). While someone born into the climate that existed in 1990 would already have a very high (98%) probability of experiencing a 1-in-100-year heatwave event during an average 70-year lifespan, this increases to almost 100% for someone born in 2025.

Figure 45. **Projected lifetime probability of experiencing a 1-in-100-year heatwave event**



Source: UNDRR, with adapted data from Thiery et al. (2021)[50]

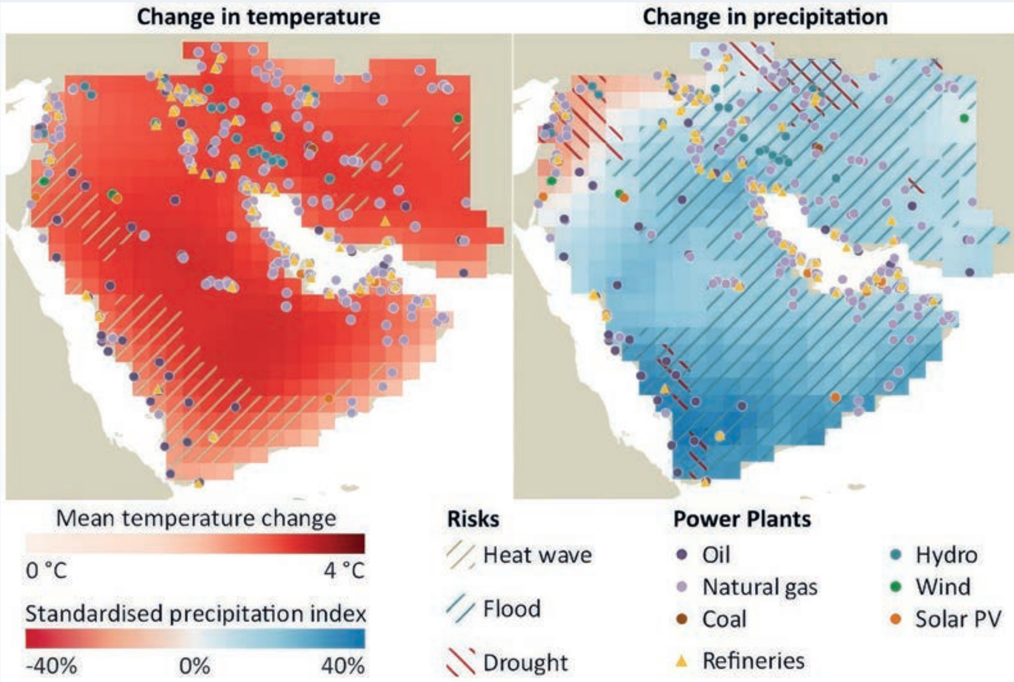
Box 27. Investing in a more climate-resilient future for Oman

The impact of rising temperatures and heat waves is projected to be especially severe in Oman. Under a high-emissions scenario (RCP8.5), the mean annual temperature is expected to increase by about 5°C on average between 1990 and 2100. During this period, the number of days experiencing a heatwave annually is predicted to rise from fewer than 15 to about 280 days on average in 2100.[51] At the same time, water scarcity is already intensifying, resulting in higher energy consumption levels when operating the country's desalination plants. At present, desalinated sea water and brackish water account for 15% of the national water supply and over 80% of its potable water supply.

Given these concerning projections, national authorities want to establish a more sustainable future under the Oman Vision 2040. Its objectives include supporting a phased transition to a low-carbon economy, built on renewable energy sources and improved energy efficiency. At present, it aims to achieve 35–39% of its energy use through renewable sources by 2040. The government is taking steps to integrate climate resilience protocols into its energy policies and invest in low-carbon, energy-efficient technologies and flood protection.

Zooming out, the challenges facing Oman are replicated across the Middle East. Between 1980 and 2023, rainfall variability increased while surface temperatures rose by around 0.5°C per decade, more than double the global average of around 0.2°C per decade.[52] Without a drastic change in policy, the mean temperature in 2041–2060 in the region will be around 2.8°C higher than pre-industrial levels, significantly higher than the global average increase of 2.1°C in this scenario.[53] As heatwaves become more frequent and severe, energy consumption for cooling will rise, reducing the efficiency of power plants. In addition, approximately 80% of natural gas plants and oil refineries and 60% of oil-fired plants in the region are expected to face a more than 10% increase in one-day maximum precipitation levels, increasing the probability of power cuts and malfunctions due to flash flooding (Map 43).[54]

Map 43. **Temperature and precipitation change in the Middle East, 2041–2060**



Source: IEA (2024), World Energy Outlook 2024, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2024,

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Notes: Heat wave risk areas see 40 more days with maximum temperatures higher than 35 °C in 2041-2060 compared with the baseline. Drought risk areas see ten more consecutive dry days. Flood risk areas see at least a 10% increase in one-day maximum precipitation. Only power plants with an installed capacity above 100 megawatts are shown.

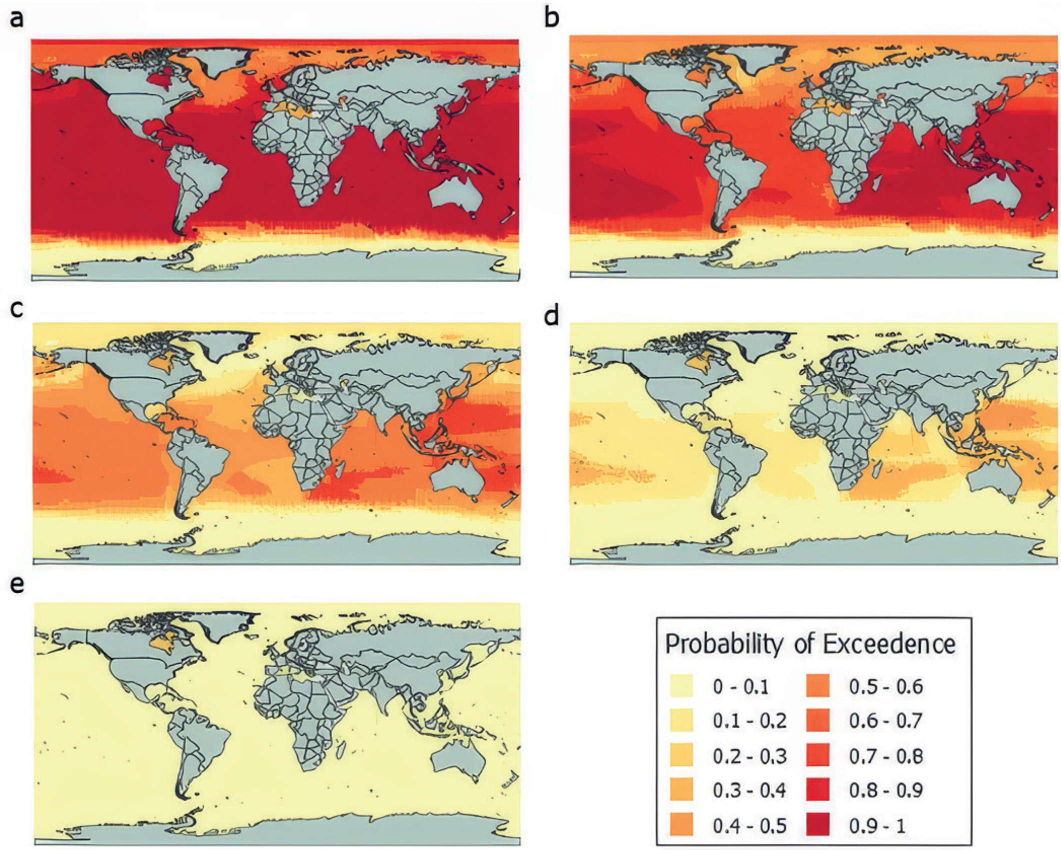
Global sea-level rise

Improved probabilistic risk models can also be used to better understand the potential impacts of future sea level rise and how this may impact regular flood events.[55] Sea-level rise represents one of the most concerning disaster risk developments, with coastal areas and island states especially exposed to a range of challenges including flooding, saltwater intrusion and the degradation of agricultural land. The continued development of housing and infrastructure in low-lying areas already exposed to flood risk. It means that the potential impacts will likely multiply in the coming decades.

According to some projections, by 2050, around 800 million people will live in cities exposed to a sea-level rise of 0.5 metres or more, with costs potentially reaching $1 trillion.[56] In some cities, there is a real danger that, without effective action, many urban residents will be forced to relocate in future to escape these impacts.

Many mid-latitude coastal regions face greater than an 80% chance of seeing sea levels exceed 0.5 meters by 2100 under certain scenarios, dramatically increasing the frequency of damaging floods (Map 44). Under higher-emission pathways (like RCP8.5), some models project a discernible risk of reaching or exceeding one meter in mean sea level, thereby turning events that were once rare into routine threats for low-lying cities.

Map 44. **Probabilities of joint 2006-2100 thermosteric, dynamic, glacier, and ice sheet sea-level rise exceeding (a) 0.5 m, (b) 1 m, (c) 2 m, (d) 3 m, and (e) 4 m**



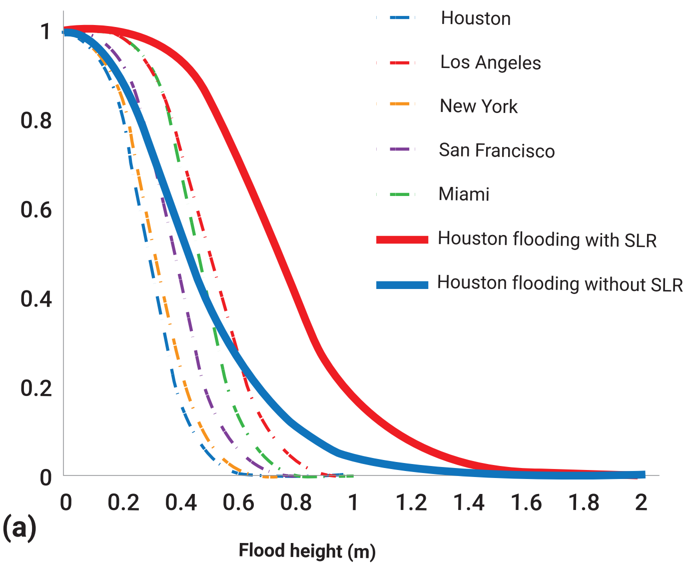
Source: Thomas, M. A., Lin, T. (2020). Illustrative Analysis of Probabilistic Sea Level Rise Hazard. Journal of Climate, 33(4), 1523-1534. https://doi.org/10.1175/JCLI-D-19-0320.1

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Note: Probabilities of joint 2006-2100 thermosteric, dynamic, glacier, and ice sheet sea-level rise exceeding (a) 0.5 m, (b) 1 m, (c) 2 m, (d) 3 m, and (e) 4 m.

For example, projected sea-level rise is expected to be significant for many major cities in the United States, with serious repercussions for their overall flood risk. Figure 46 illustrates how sea-level rise contributes to increased coastal flooding risk in cities like Houston, Texas.

Figure 46. **Sea-level rise and projected flood risk in Houston and selected cities in the United States**



Source: (Luo and Lin 2023)

Note: Sea-level rise hazard curves (dashed lines) of five US coastal cities, including Houston, Los Angeles, New York, San Francisco and Miami, and flooding hazard curves for Houston with and without sea level rise.

For better or worse, the decisions made today will shape the lives of future generations in many ways. This is illustrated by two very different possible futures, "Generation Jolt" and "Generation Regeneration", developed by the United Nations Future Lab to illustrate the potential directions the world might take between now and 2050. On the one hand, Generation Jolt exemplifies the extremes of a high-risk, high-regret future, where resilience investment is lacking, and extreme climate and disaster impacts take a toll on people, planet and prosperity. On the other hand, Generation Regeneration envisions a comprehensive approach to resilience-building, driven by renewed global cooperation, flexibility to adapt, a transformation in value systems and a revolutionized financial sector.

Generation Jolt

Navigating The Global Crossroads Of Disaster Risk

The year is 2025, and the world has reached a precarious tipping point, driven by a series of cascading crises. **Climate change** has accelerated beyond predictions, leading to a **loss of biodiversity** that has reached catastrophic levels. **Critical ecosystems** like rainforests and coral reefs are collapsing, triggering a **global ecological crisis** that threatens the foundations of life on Earth. The global temperature has risen by an alarming 1.5 to 2.0 degrees Celsius, causing extreme weather events, rising sea levels, and increased frequency of natural disasters, which have become the new norm.

Economic instability and **geopolitical tensions** have fractured the global order, leading to widespread distrust in institutions and a rise in **nationalism** and **populism**. The erosion of human rights and the collapse of governance in fragile states have further exacerbated vulnerabilities. Access to basic needs like water, food, healthcare, and education has become increasingly restricted, particularly in regions already struggling with inequality and poverty. These conditions have deepened gender inequalities and worsened the plight of marginalized communities, leading to a surge in health impacts and socio-economic disparities across the globe.

The world's descent into this crisis has been driven by several interconnected forces:

01 Geopolitical Crises:
Persistent conflicts over resources, coupled with the breakdown of global cooperation, have created a volatile international environment. The rise of **non-state actors** and the erosion of multilateral institutions have left many nations vulnerable to **external shocks** and internal strife.

02 Economic Instability:
A global financial crisis has exacerbated inequalities, with the **deregulation of markets** and the **shifting power dynamics** between state and **non-state actors** further destabilizing economies. **Youth unemployment** and **investment pathways** focused on short-term gains rather than sustainable development have contributed to the erosion of trust in economic systems.

03 Technological Disruption:
Rapid advancements in technology, particularly in AI and automation, have led to widespread **job displacement**, deepening economic inequality and social unrest. The misuse of technology by authoritarian regimes has also contributed to the erosion of privacy and civil liberties.

04 Environmental Degradation:
The collapse of key ecosystems has led to severe food **scarcity** and the spread of **zoonotic diseases**, overwhelming global health systems. Resource conflicts have intensified, driving mass migration and displacement.

05 Social Fragmentation:
The mental health crisis, exacerbated by economic depression and social isolation, has strained communities and increased social tensions. The rise of **populism** and **misinformation** has further fragmented societies, weakening the social fabric and undermining

The consequences of these developments are severe:

06 Global Conflicts:
The competition over scarce resources and ideological divides has fueled global conflicts, leading to **political instability** and **violent extremism**. As trust in institutions erodes, communities become more fragmented, and the risk of civil unrest rises.

07 Environmental Catastrophes:
The tipping point of environmental degradation has been reached, with **food insecurity** becoming a global issue. The collapse of ecosystems has triggered a cascade of health crises, including the resurgence of pandemics linked to climate change and biodiversity loss.

08 Economic Disruption:
The financial crisis has led to a breakdown of social safety nets, with the most vulnerable populations suffering the most. The **digital divide** has widened, creating a new class of disenfranchised individuals unable to access basic services or participate in the digital economy.

09 Societal Collapse:
As governance structures weaken, the risk of **societal collapse** increases, particularly in regions already struggling with **fragile states** and **failed governance**. The erosion of trust in leadership and institutions accelerates the breakdown of social order.

Actions and Actors

To navigate this precarious future, several actions and key actors must emerge:

Strengthening Governance:
International organizations like the UN must push for renewed global agreements focused on climate action and disaster risk reduction. Strengthening governance in fragile states and protecting human rights are essential to preventing further collapse.

Investing in Resilience:
Financial institutions and the private sector must pivot towards sustainable practices, investing in green technologies and resilient infrastructure. This shift requires innovation in policy, technology, and societal norms, with a focus on long-term stability over short-term gains.

Empowering Civil Society:
The role of NGOs and civil society is critical in advocating for those left behind and ensuring that emergency aid reaches those in need. Local communities must be empowered to build resilience from the ground up, particularly in regions most vulnerable to climate impacts.

Harnessing Technology for Good:
The role of NGOs and civil society is critical in advocating for those left behind and ensuring that emergency aid reaches those in need. Local communities must be empowered to build resilience from the ground up, particularly in regions most vulnerable to climate impacts.

Building Trust:
Rebuilding trust in institutions and leadership is crucial. This requires transparency, accountability, and a commitment to inclusive governance that addresses the needs of all populations, particularly the most vulnerable.

Source:
Content developed by the UN Futures Lab for GAR 2025,
UNDRR original graphic developed for GAR 2025

Generation Regeneration

Regeneration for Resilient Futures

In 2025, the world stands at a pivotal moment where past decisions and the immediacy of current challenges necessitate a **strategic shift in investments to enhance resilience and sustainable development.** There is **aresurgence in multilateralism**, where nations and international bodies commit to **collective resilience. Investments** focus on reinforcing international frameworks that facilitate global cooperation, ensuring that no one is left behind. This includes establishing **financial oversight mechanisms** to guarantee that investments are equitably distributed and that all communities benefit. In response to escalating environmental changes and socio-economic shifts, the world prioritizes **investments in agile and adaptable systems.** Financial resources are directed towards **innovative technologies and governance structures** that can swiftly respond to emerging risks, enhancing global resilience. **Transformation of Value Systems:** Societies undergo a significant shift towards **valuing environmental stewardship, social equity, and sustainable growth.** Investments reflect this change, driving **ethical economic practices** and consumer **behaviors that support long-term resilience.** The financial sector experiences a profound transformation, with **sustainable and green finance becoming mainstream**. Investments are redirected towards projects that support the **transition to a low-carbon economy, foster innovation in clean technologies,** and ensure that financial flows contribute to global resilience rather than exacerbate vulnerabilities.

Key Drivers and Strategic Investments for Resilience

01 Technological Innovation for Resilience:
Investments in AI, biotechnology, and cutting-edge research are pivotal. These technologies enhance disaster risk reduction by improving forecasting, resource management, and crisis response. Strategic investment in biotechnology also supports sustainable agriculture and public health, reinforcing societal resilience.

02 Governance and Policy Reforms:
Governments and international bodies implement policy reforms aimed at sustainability and equity, supported by targeted investments. Financial tools are developed to incentivize green technologies, protect ecosystems, and ensure social justice, balancing economic growth with environmental stewardship.

03 Private-Public Sector Collaboration:
Significant investments flow into partnerships between the private and public sectors. These collaborations are crucial in scaling up sustainable innovations and ensuring that technological advancements are accessible and beneficial to all, reinforcing global resilience.

04 Local Community Empowerment
Investments prioritize empowering local communities to participate actively in decision-making processes. Funding is directed toward enhancing public engagement through transparent governance and inclusive policies, ensuring that local voices shape resilience strategies and benefit from global investments.

05 Youth and Education for Resilient Futures
Investments in education systems are critical, reforming them to emphasize critical thinking, sustainability, and social responsibility. These investments prepare the next generation to lead in an increasingly complex world, ensuring a resilient future.

Implications and Consequences of Investing in Resilience

06 Migration and Economic Stability:
Strategic investments in managing migration flows close skill gaps, enhance local economies, and reduce social tensions. The transition to a green economy is supported by sustainable finance, though market instability may occur as industries adapt to new norms.

07 Social Cohesion and Equity:
Investments in inclusive governance and equitable resource distribution rebuild social trust. As societies shift towards new value systems, concepts of freedom and fairness are realigned, though conflicts may arise from entrenched interests, requiring careful investment in conflict resolution mechanisms.

08 Environmental Resilience:
Focused investments in sustainability lead to significant environmental improvements, including better resource management and reduced carbon emissions. Proactive conservation efforts, supported by strategic investments, preserve biodiversity and restore ecosystems, contributing to resilience against climate-related disasters.

09 Technological and Economic Transitions:
Investments in new technologies reshape job markets, directing labor towards sustainable sectors. Traditional industries face the need to adapt or risk obsolescence, necessitating investments in robust social safety nets and retraining programs to support affected workers.

10 Global Health and Well-being:
Investments in social equity and environmental health improve global well-being. Access to healthcare, education, and clean energy becomes more widespread, reducing inequalities and enhancing quality of life.

Actions to pre-empt set-backs

Stress Testing the Scenario:

The Regeneration for Resilient Futures scenario undergoes rigorous stress testing to identify potential challenges. Key stressors include the risk of misinformation undermining investment efforts, the possibility of technological advancements exacerbating inequalities, and potential economic disruptions during the transition to sustainable practices.

Wildcards

Unforeseen events or "wildcards" could significantly impact the scenario's outcomes. These include rapid technological deployments in unexpected sectors, geopolitical shifts affecting global investment flows, and sudden environmental crises. The scenario anticipates these wildcards by ensurin that investments are flexible and adaptive, capable of responding to unforeseen challenges.

Source:
Content developed by the UN Futures Lab for GAR 2025,
UNDRR original graphic developed for GAR 2025

Recommendations for action

Risks can be transformed into opportunities through investments in resilience building. At present, however, while resilient investments can yield considerable benefits, often repaying their upfront costs many times over, private sector adaptation and resilience investment and official development assistance (ODA) funding remain insufficient, particularly in developing countries.

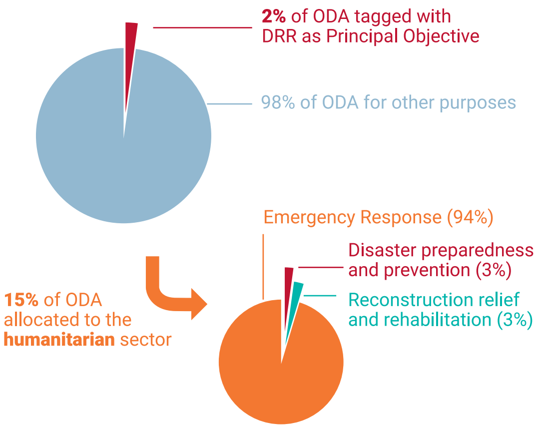
Given the potential costs of inaction, the stakes could not be higher. A growing body of research clarifies that disaster losses are already considerably larger than the costs of disaster risk reduction.[57] This is particularly true once the potential compounding economic benefits of disaster risk reduction and climate change adaptation are factored in. For example, long-term savings from investment in resilience and coping mechanisms can reach 300% for droughts and 1,200% for storms in sub-Saharan Africa.[58] These substantial benefits are often recorded against programs like installing disaster preparedness and public health measures with low costs and high benefits. High benefits are also found in contexts where adaptation involves marginal shifts in production, such as when farmers switch crops or when improvements in building design help prevent the collapse of infrastructure.[58] Indeed, some sectoral studies report benefit-cost ratios of between 100% and 900% for climate adaptation measures.[59]

To succeed, however, adequate investment in resilience is needed at scale. At present, however, there remains a considerable funding gap in translating disaster resilience policies into concrete actions, evident even within the climate change adaptation community. For instance, a recent survey of selected National Adaptation Plans found that around half had failed to cost the financial outlay required to implement them adequately.[60] This reflects a wider global mismatch between the adaptation financing levels needed and what is available, particularly in low-income countries.

Between 2019 and 2023, about 1% of total ODA was officially categorized as disaster risk reduction, prevention, and preparedness. Looking exclusively at the humanitarian sector, disaster prevention and preparedness accounted for only about 3.3% of humanitarian aid for 2019-2023, down from 3.6% for 2015-2018. Even when projects that include DRR as an objective within broader sectoral projects targeting the health, transport, and agricultural sectors, the share of ODA contributing to DRR rises to 2% on average.

Figure 48. **International Development Cooperation**

Total Official Development Assistance (ODA)



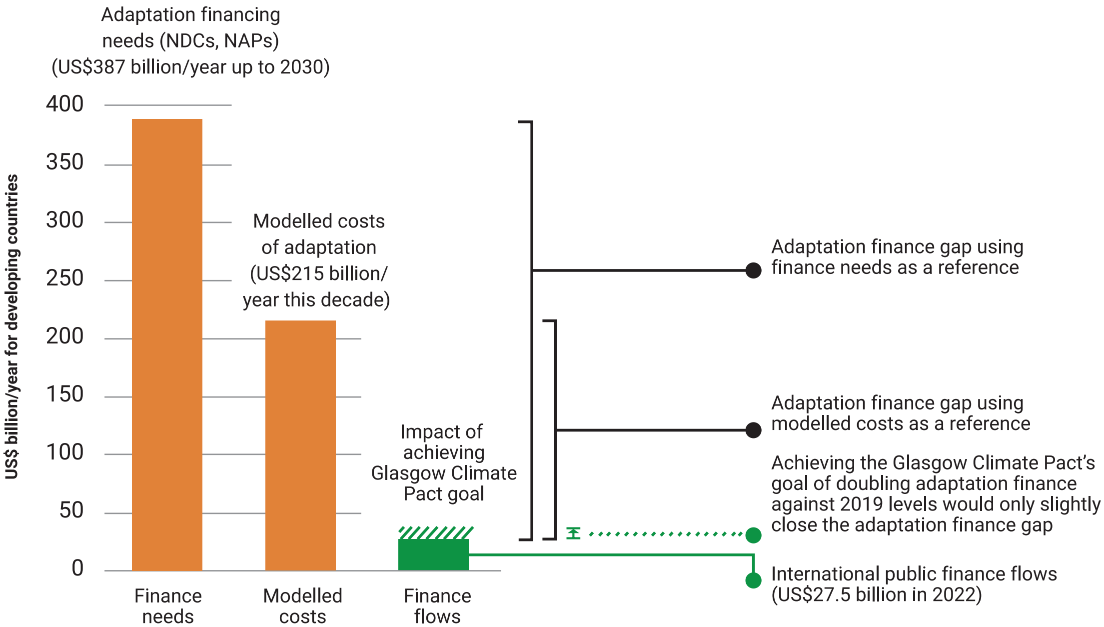
Key messages

- Only 2% of total ODA have DRR as an objective
- Only 3% of humanitarian-related ODA to disaster preparedness and prevention (no change since 2015)
- In 2024, only 43% of the estimated humanitarian needs were funded
- Uncertainty around ODA and unavailability for small-scale events

Source: UNDRR based on OECD DAC Data 2019-2023

The annual financing needs and modelled adaptation costs for developing countries are considerably larger than current finance flows (Figure 49). Even if the 2019 Glasgow Climate Pact's target of doubling the adaptation finance available for developing countries is achieved, this would only address a small portion of the deficit.

Figure 49. Comparison of adoption financing needs, modelled costs, and international public adaptation finance flows in developing countries

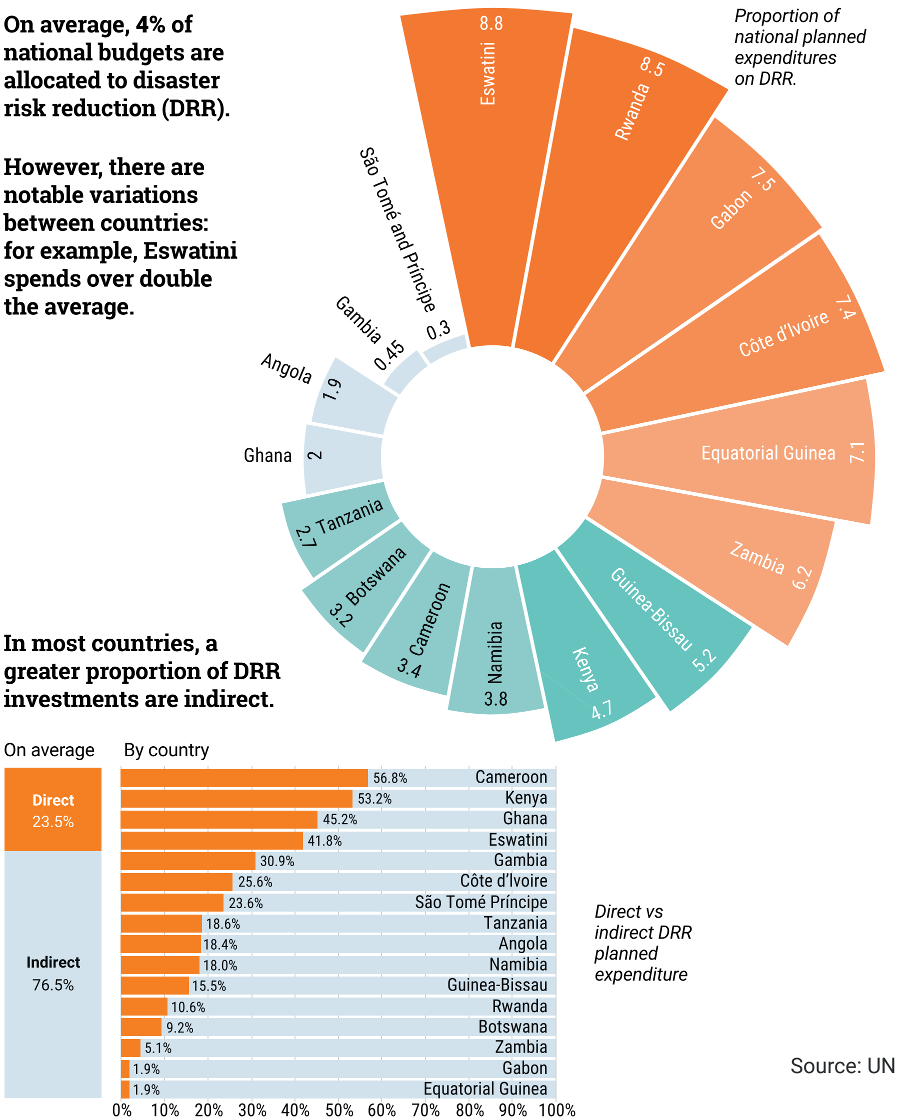


Source: (UNEP et al. 2024)

According to recent estimates, adaptation financing needs in countries in the Global South are currently 10–18 times larger than the finance flows available.[61] This situation is partly because disaster risk reduction is still poorly prioritized even within global development assistance, accounting for less than 0.5% of total expenditure. An additional challenge is that available funding disproportionately focuses on responding to, rather than anticipating, disasters. For instance, between 2005 and 2017, of the $137 billion provided in development assistance related to disasters, 96% was spent on emergency response, reconstruction, relief and rehabilitation. Less than 4% ($5.2 billion) was invested in disaster prevention, mitigation and preparedness.[62] Given the clear benefits of prevention, this is an increasingly inefficient investment approach unsuited to the current and future risk landscape.

For example, risk-sensitive budget reviews that UNDRR carried out for 16 African countries between 2018 and 2019 showed that on average, total DRR investments represented 4% of national budgets (Figure 50). Direct DRR spending has a share of 1% in national budgets on average. In contrast, indirect spending, accounted for through budget activities significantly related to DRR but not necessarily carried out with DRR as their primary objective, represents, on average, 3% of national budget estimates.

Figure 50. **Disaster risk reduction investments in Africa**



Source: UNDRR, 2020.

Mobilizing private finance is particularly important for low-income countries. All countries must become more resilient, but effective efforts must be global, given current economic inequalities. By way of illustration, in 2022, low-income countries received only around 2% of global foreign direct investment.[63] A lack of risk understanding cannot be allowed to let this figure fall even further, particularly given the significant potential for growth and development in these regions. A more sustainable future is possible, urgent and affordable, but it will require a strong evidence base to guide future investment strategies and sufficient resources to ensure these are properly realized.

Creating a sustainable future for future generations will require a concerted shift from managing disasters after they occur to proactively reducing risks on the horizon. The choices countries, communities and households make now can play a critical role in the resilience or vulnerability of generations to come. Understanding potential impacts and the associated costs these will incur provides a valuable foundation for developing informed, innovative strategies to reduce their severity. Ultimately, understanding the nature and extent of future disaster risk is an essential first step to towards a sustainable future.

[1]Royal Society, 2023. P4.

[2]UNDRR, 2023

[3]CRED and UCLouvain, 2025. Extracted the 22 January 2025.

[4]Calderon and Silva, 2022

[5]Calderon & Silva, Forecasting seismic risk within the context of the Sendai framework: An application to the Dominican Republic, 2022

[6]Hoyos and Silva, 2022

[7]Lewis Djikstra, JRC personal communication March 3, 2025 using data from the forthcoming World Urban Prospects, 2025

[8]Most people are living the global south (83% in 2020) the population the global south is projected to grow by 1.8 billion between 2020 and 2050, while the population in the global north is projected to shrink by 20 million. The only reason the city population in the global north is still growing is because the increase in the share of city population compensates for the reduction in the overall population.

[9]Case study developed for GAR 2025, Pondard, Poulter et al.

[10]GIRI considers the following categories of infrastructure: buildings across multiple subsectors, including residential, industrial, government, healthcare, and education & roads and railways, water and wastewater systems, communications, oil and gas, transport, and power networks

[11]The estimates presented in Figure 4 are based on projected changes in extreme climate events under different global warming scenarios. The 1.5°C scenario represents a world where warming is limited to 1.5°C above preindustrial levels (1850–1900), consistent with the most ambitious target of the Paris Agreement. The 2.0°C scenario corresponds to a 2.0°C warming limit, which is the upper boundary set in the Paris Agreement to reduce severe climate risks. The "Current Pledges" scenario reflects global warming levels expected based on current national policies and climate commitments (NDCs, Nationally Determined Contributions), leading to an estimated warming of approximately 2.6°C to 3.0°C by 2100 if all pledges are fully implemented. These scenarios align with Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs) used in climate modeling. The 1.5°C and 2.0°C scenarios are roughly associated with RCP2.6 and RCP3.4, which represent low greenhouse gas emissions pathways. The "Current Pledges" scenario aligns more closely with RCP4.5 to RCP6.0, which correspond to intermediate emissions pathways leading to higher warming levels.

[12]Thiery et al., 2021

[13]Jaramillo, Diana and Pant, Raghav, 2023

[14]Tropical cyclones are violent hydrometeorological hazards which are affecting regions where ocean water temperatures are above 26°C, low pressure and have vertical atmosphere stability. The equator is preserved from these hazards as the coriolis force is null and prevent the formation of tropical cyclones.

[15]Intergovernmental Panel On Climate Change (Ipcc), 2023

[16]Hall et al., 2024

[17]The estimates presented in Figure 42 are based on projected changes in extreme climate events under different global warming scenarios. The 1.5°C scenario represents a world where warming is limited to 1.5°C above preindustrial levels (1850–1900), consistent with the most ambitious target of the Paris Agreement. The 2.0°C scenario corresponds to a 2.0°C warming limit, which is the upper boundary set in the Paris Agreement to reduce severe climate risks. The "Current Pledges" scenario reflects global warming levels expected based on current national policies and climate commitments (NDCs, Nationally Determined Contributions), leading to an estimated warming of approximately 2.6°C to 3.0°C by 2100 if all pledges are fully implemented. These scenarios align with Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs) used in climate modeling. The 1.5°C and 2.0°C scenarios are roughly associated with RCP2.6 and RCP3.4, which represent low greenhouse gas emissions pathways. The "Current Pledges" scenario aligns more closely with RCP4.5 to RCP6.0, which correspond to intermediate emissions pathways leading to higher warming levels.

[18]CDRI, 2021

[19]CDRI, 2021

[20]CDRI, n.d.

[21]Goldberg et al., 2020

[22]Mo, Simard and Hall, 2023

[23] EM-DAT, CRED / UCLouvain, 2025, Brussels, Belgium. Data downloaded 22 January 2025

[24]CDRI, 2023. Data downloaded 4 February 2025

[25]Mudenge et al., 2023

[26]WMO and Global Water Partnership, 2013.

[27]UNCCD, n.d.

[28]UNCCD and FAO, 2024

[29]UNDRR, 2021

[30]The estimations presented in this chart are based on projected changes in extreme climate events under different global warming scenarios. The 1.5°C scenario represents a world where warming is limited to 1.5°C above preindustrial levels (1850–1900), consistent with the most ambitious target of the Paris Agreement. The 2.0°C scenario corresponds to a 2.0°C warming limit, which is the upper boundary set in the Paris Agreement to reduce severe climate risks. The "Current Pledges" scenario reflects global warming levels expected based on current national policies and climate commitments (NDCs, Nationally Determined Contributions), leading to an estimated warming of approximately 2.6°C to 3.0°C by 2100 if all pledges are fully implemented. These scenarios align with Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs) used in climate modeling. The 1.5°C and 2.0°C scenarios are roughly associated with RCP2.6 and RCP3.4, which represent low greenhouse gas emissions pathways. The "Current Pledges" scenario aligns more closely with RCP4.5 to RCP6.0, which correspond to intermediate emissions pathways leading to higher warming levels.

[31]Davis, 2016.

[32]Bonnet et al., 2024.

[33]UNCCD, 2022.

[34]UNCCD, 2023.

[35]UNCCD, 2024.

[36]ITPS and FAO, 2015

[37]Convention on Biological Diversity, 2020.

[38]UNCCD, 2022

[39]IPBES et al., 2018

[40]FAO, 2019

[41]FAO, 2017.

[42]Davis, 2016

[43]Bonnet et al., 2024

[44]United Nations Secretary-General, 2024.

[45]Future Earth Issue Brief Heatwave, 2019

[46]Mani et al., 2018

[47]IEA, 2024.

[48]IEA, 2024.

[49]The estimations presented in this chart are based on projected changes in extreme climate events under different global warming scenarios. The 1.5°C scenario represents a world where warming is limited to 1.5°C above preindustrial levels (1850–1900), consistent with the most ambitious target of the Paris Agreement. The 2.0°C scenario corresponds to a 2.0°C warming limit, which is the upper boundary set in the Paris Agreement to reduce severe climate risks. The "Current Pledges" scenario reflects global warming levels expected based on current national policies and climate commitments (NDCs, Nationally Determined Contributions), leading to an estimated warming of approximately 2.6°C to 3.0°C by 2100 if all pledges are fully implemented. These scenarios align with Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs) used in climate modeling. The 1.5°C and 2.0°C scenarios are roughly associated with RCP2.6 and RCP3.4, which represent low greenhouse gas emissions pathways. The "Current Pledges" scenario aligns more closely with RCP4.5 to RCP6.0, which correspond to intermediate emissions pathways leading to higher warming levels.

[50]IEA, 2023.

[51]IEA, 2024.

[52]Intergovernmental Panel On Climate Change (Ipcc), 2023.

[53]IEA, 2024

[54]For instance, the Global Sea-Level Rise Model (GSLRM) builds upon Probabilistic Sea-Level Rise Hazard Analysis, embracing both probabilistic and process-based approaches (PSLRHA). Inspired by Probabilistic Seismic Hazard Analysis and climate science, PSLRHA incorporates aleatory and epistemic uncertainties from climate forcing, models, and contributing physical processes, including polar ice melting especially in Antarctica and Greenland. The core methodology from GSLRM is transferrable to other climate-induced hazards and novel multi-hazard combinations across temporal and spatial scales, with broader implications for global models. Lin, 2012.

[55]C40 Cities Climate Leadership Group, 2018

[56]Aligishiev, Bellon, and Massetti, 2022.

[57]Aligishiev, Bellon, and Massetti, 2022.

[58]UNEP et al., 2024.

[59]Hallegatte, Rentschler and Rozenberg, 2019.

[60]UNEP et al., 2024.

[61]UNEP, 2023

[62]UNDRR, 2020b

[63]CDRI, 2023


DEBT
DEBT
DEBT

CHAPTER 6

Investing in resilience for economic stability

There is a stark mismatch between the increasing levels of global disaster risk detailed in previous chapters of this report and current investment in resilience. Disasters already exert a substantial macroeconomic toll, from weather-related events such as floods, storms, drought an d extreme heat to major hazards like earthquakes. The toll is expected to rise sharply as such events become more frequent and severe.[1] Without urgent action to close the gap between risk and investment, the financial and economic consequences will become increasingly difficult to manage.

When disasters occur repeatedly, economic growth often slows and debt increases. Developing countries, particularly small island developing states (SIDS) and least developed countries (LDCs), face the dual challenge of higher exposure to hazard risk and limited access to resources for risk reduction. In such situations, it becomes increasingly expensive to insure or otherwise transfer risk, and more money is spent on humanitarian responses when disasters are not prevented. This high cost is not inevitable. To create a more stable investment climate, governments, multilateral institutions, the private sector and households must rethink and realign their investments to better protect current and future assets. A clear, integrated risk financing approach can help address these challenges and open a pathway toward long-term financial and economic stability.

This chapter presents three interconnected negative feedback loops, or "spirals", that illustrate how disaster risk can destabilize economies, contributing to declining incomes, rising debt, unsustainable risk transfer and repeated cycles of response and recovery. These unsustainable development spirals feed into one another, meaning that failure to address one can intensify vulnerabilities elsewhere.

To counter these trends, this chapter also outlines a series of public and private actions that can shift the disaster risk narrative, from one of rising costs and instability to one of resilient, inclusive and sustainable development.

Risk reduction investments can generate financial returns while strengthening operational security for the private sector. These benefits are amplified when the public sector complements these actions by strengthening policy frameworks and prioritizing resilience in its own investment decisions.

Such proactive disaster risk management is not only possible; it is profitable. Tools already exist to achieve this, but they must be scaled up and applied more consistently. Such a shift to proactive disaster risk management will yield a triple dividend: economic stability, enhanced resilience and increased private sector investments and opportunity.

Components of a risk financing strategy

To be effective, disaster risk management strategies should maximize cost-effective risk prevention and share residual risk widely, while aiming to retain only a minimum level of risk where reduction is unfeasible. These strategies must be tailored to local circumstances.

Figure 51. **Risk reduction, retention and transfer as domains of resilient investment**

	UNDRR definition	Examples	Advantages	Limitations
Risk reduction	Steps taken to prevent new and reduce existing disaster risk and manage residual risk, thereby strengthening resilience and sustainable development	• Effective enforcement of land-use plans to prevent future disasters • New hazard-resilient infrastructure • Retrofitted infrastructure	• Cost-effective • Accelerates wider SDG achievement	• Requires up-front costs • Unrealized losses of effectively averted disasters hard to quantify
Risk transfer	The process of formally or informally shifting financial consequences of risks from one party to another, whereby a household, community, enterprise or State authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party	• Disaster insurance • Community savings groups prioritizing disaster-affected members	• Enables public-private risk sharing over wider geographic areas • Risk pools can share risk within and across the public sector	• Rising disaster frequency undermines affordability and insurability • Must be designed with a build-back-better approach to build resilience • Must provide multi-year coverage
Risk retention (aka residual risk)	Disaster risk that remains unmanaged, even when effective DRR measures are in place, and for which emergency response and recovery capacities must be maintained	• Government anticipatory action • Disaster response fund for humanitarian relief	• Enables rapid deployment of assistance without the need to pay premiums	• Higher cost per unit of support • May not be sufficient to cover very large events

Source: UNDRR terminology (2009/2017)

Risk reduction is the cornerstone of effective disaster risk management, but its impact is highest when combined with risk transfer and well-designed responses to residual risk. The optimal mix will vary by context, but together these three elements form a powerful strategy for breaking the negative spirals of unsustainable risk management, detailed above. (Figure 51)

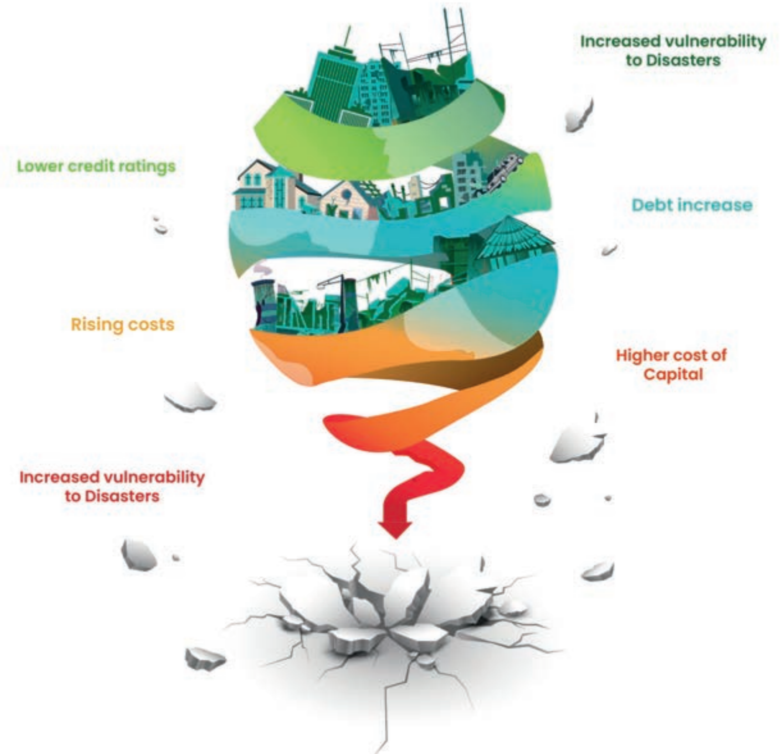
The three negative spirals of unsustainable disaster risk management

All three negative spirals discussed in this section are associated with failing to reduce, retain or transfer risk. Each spiral holds back future sustainable development in a different way. Good finance and investment strategy choices can slow or prevent the spirals from forming and contribute to more sustainable, transformative risk management.

The decreasing income, increasing debt spiral

Sudden events like earthquakes or major cyclones can wipe out decades of development in minutes. Extensive, slower-onset events undermine progress over time, often in the areas that need it most. The first negative spiral (Figure 52) occurs when a lack of disaster risk reduction leads to recurrent excessive losses, reducing household income and depleting national assets.

Figure 52. **The decreasing income debt spiral**



Source: Adapted from Ranger et al. (2024)

As outlined earlier in this report, disasters cause long-term household income losses, pushing many into poverty. Disaster impacts manifest in ways that stretch far beyond the direct and immediate damage of a shock event. For instance, households often face challenges allocating their resources for quick disaster recovery. In many cases, the share of income lost is greatest among the poorest households. Damage to their assets and disruptions in the workplace can also reduce their income. Households must decide whether to invest in reconstruction (potentially increasing their indebtedness) or cut their essential consumption. Some households may choose not to invest in reconstruction, which can prolong income losses and permanently impact wellbeing.[2]

However, given the interconnectedness of today's economic systems, even relatively localized disaster-related impacts can have wider repercussions on national and global economies. When households and businesses incur losses in the wake of disasters, many households cut their expenditure while companies are forced to reduce their investments in growth. This, along with redirecting government funds to provide urgent emergency relief, can cause the overall economy to shrink. Since GDP is essentially the sum of what consumers spend, businesses invest and governments fund, and the trade balance, these reductions often add up to a lower GDP.

This is most visible in smaller economies, like those of SIDS and LDCs, where disaster losses can represent a significant share of GDP, limiting growth and recovery potential. Overall, the aggregate income losses could be substantial. As outlined in the previous chapter, recent models suggest that by 2050, global incomes could decline by 19% on average due to climate-related hazards, with lower-income countries suffering disproportionately.[3]

Major or frequent disasters can disrupt the balance between income and spending, making it harder for governments to adhere to fiscal rules. This disruption can undermine productivity and output, affecting countries' sovereign risk (Figure 53). Improper pricing, when the risks associated with disasters and climate change are not adequately reflected in sovereign credit ratings, can lead to misalignment if the sovereign debt deteriorates due to the impacts of climate change.[4]

Corporate credit ratings must also account for disaster and climate risks to ensure an accurate assessment of financial stability and encourage consideration of resilience measures.

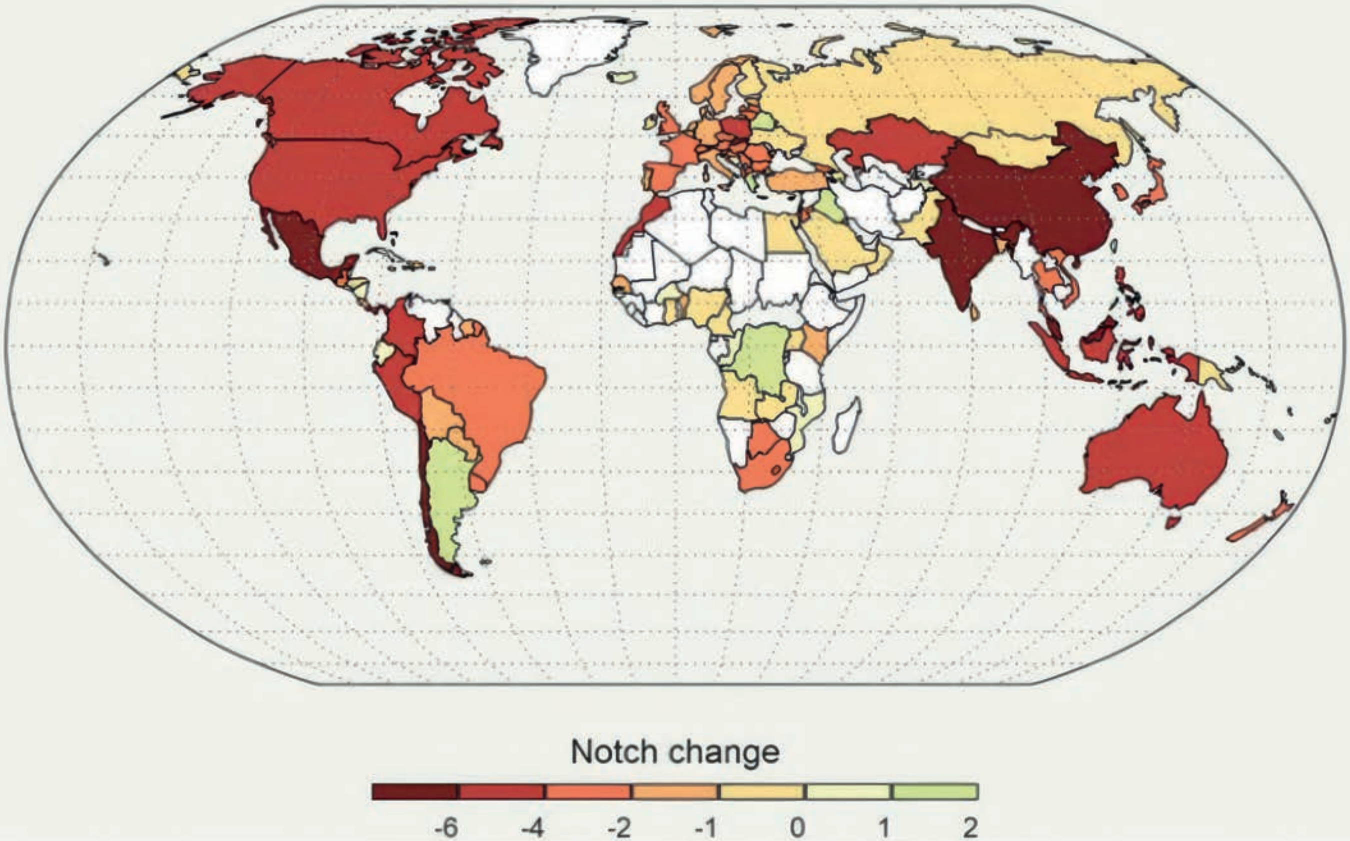
Figure 53. **Disaster and sovereign risk: Key investment impacts pathways**

Source: Adapted from Agarwala et al., 2024

Improper pricing and unmanageable disaster-related economic losses can drive indirect impacts such as sovereign credit downgrades, significantly raising borrowing costs for affected nations. As credit ratings fall, the price of money not only increases for "riskier" countries' governments but also private borrowers in international markets, leading to higher interest payments on public and private debt, often by a significant amount, as evidenced by the example of Thailand outlined below (Box 29). Such trends are also of concern in regions beyond Asia. For example, recent projections have estimated that a 2.5-notch credit rating downgrade for Jamaica could increase annual debt servicing costs by $270 million.[5]

Arguably, these impacts are already starting to be considered. As shown on Map 45, a 2023 analysis of 109 countries suggests that by 2030, nearly half could face climate-induced credit downgrades. These projections highlight systemic financial risks, even without accounting for extreme events or tipping points. Downgrades raise borrowing costs, further straining disaster-prone nations. In a worst-case scenario, this could lock low-income countries into a vicious cycle whereby the rising costs of climate-related disasters increase household and national debt, reducing investment (including disaster risk reduction) and increasing vulnerability.

Map 45. Global climate change induced sovereign rating changes



Source: Klusak, Patrycja, Matthew Agarwala, Matt Burke, Moritz Kraemer, and Kamiar Mohaddes. 2023. "Rising Temperatures, Falling Ratings: The Effect of Climate Change on Sovereign Creditworthiness." Management Science 69 (12): 7468–91. https://doi.org/10.1287/mnsc.2023.4869.

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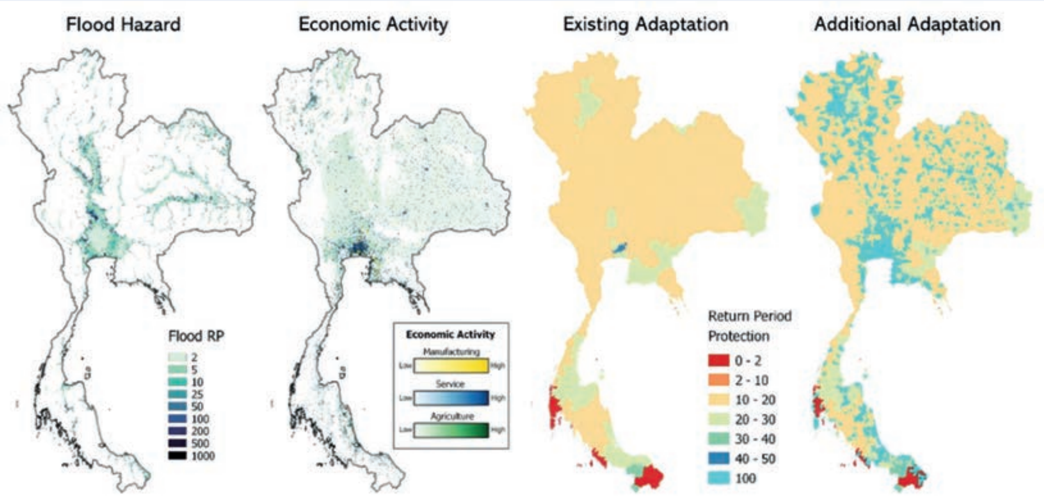
Box 29. Flood risk, sovereign credit ratings, and the benefits of risk reduction and adaptation in Thailand

The Government of Thailand has been working with a team at Oxford University, based in the United Kingdom of Great Britain and Northern Ireland, to quantitatively integrate climate risks and adaptation into sovereign credit ratings. By modelling disaster losses, their economic impact and the effects on a country's credit rating, they have simulated thousands of years of damage now and in the future, with and without additional climate adaptation. These damages are then input into a macroeconomic model that estimates how a country's economy is affected by disasters, based on a predictive sovereign credit rating model, trained on over 600 historical sovereign rating movements.[6] The result is a dynamic model that quantitatively estimates the impact of climate risks and adaptation on a country's sovereign credit rating.[7]

The model looks at current and projected risk in a high-emissions future, with and without additional adaptation, combining spatial data on flooding and economic activity to assess risk. In particular, it considers two adaptation scenarios: a baseline adaptation scenario that considers current levels of flood protection and an additional adaptation scenario where river flood protection in urban areas is increased to protect against a 1-in-100-year flood event. The inputs to the model are shown in Map 46.

Map 46. GInputs into the climate risk and adaptation model showing the impact of a 1-in-100-year flood event in Thailand



Source:Bernhofen, Mark et al "The Impact of Physical Climate Risks and Adaptation on Sovereign Credit Ratings". Available at SSRN: http://dx.doi.org/10.2139/ssrn.4950708. November 25, 2024

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

The results show that flooding could have a significant impact on Thailand's credit rating in future (Figure 54). Even today, the losses arising from a 1-in-1,000-year event could cause a two-notch downgrade. However, a future event of this scale could lead to three or four notch downgrades, depending on the emissions scenario. A downgrade of this magnitude has enormous implications, as it causes Thailand's rating to fall from investment to non-investment grade, a significantly increased risk of default, causing borrowing costs to rise, and potentially deterring investment. Such an event can generate economic instability and reduce access to international capital markets. However, action to reduce risk now can significantly reduce these impacts. For a 1-in-1,000-year event in the high-emission scenario, the model shows that additional adaptation investments can lead to avoided losses of $48 billion. It also reduces a four-notch downgrade to two notches, which could prevent increases in annual interest payments of over $2.3 billion.

Figure 54. Sovereign credit rating impacts for a 1-in-1,000-year flood event across three climate and adaptation scenarios

			1 in 1000 loss year		
Grade	Rating	Numerical	TodayF	uture	Future+ Adaptation
Investment	BBB+	13	Rating		
	BBB	12			
	BBB-	11			
Non-Investment	BB+	10			
	BB	9			

Source: Bernhofen et al., 2024

Disaster and climate risks are rising, with profound financial implications for the most exposed countries. Understanding the risks to private debt, particularly sovereign debt, the world's largest and most important asset class, is crucial from a systemic resilience perspective. Catastrophe models with economic and financial models, climate risk and adaptation, can be effectively integrated into sovereign credit rating scenarios. Scenario analysis like this could enhance investment decision-making, signalling that a country is actively addressing its climate vulnerabilities. "Adaptation smart" sovereign credit rating scenarios could also incentivize further adaptation efforts, especially if they show how resilience investments may result in avoided rating downgrades. This scenario highlights how early adaptation investments can directly reduce sovereign borrowing costs.

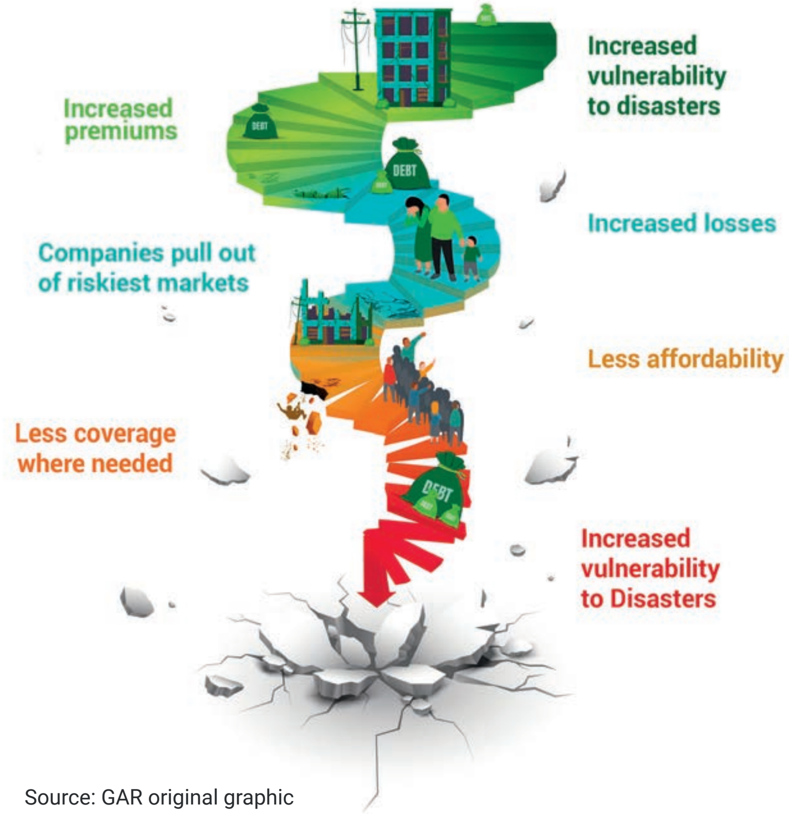
The unsustainable risk transfer spiral

Even in wealthier regions such as the European Union, only about a quarter of climate-related catastrophe losses are currently insured.[8] As a result, central governments shoulder an increasingly heavy burden of hazard-related risk. Low insurance penetration also limits the ability to share risk widely, particularly in developing countries where few assets are protected: for instance, insurance coverage remains below 1% in countries like Bangladesh, India, Vietnam, the Philippines, Indonesia, Egypt and Nigeria. Although precise figures are scarce, the gap is clear. In 2018, an estimated $163 billion of assets worldwide were underinsured, leaving an exposure gap that threatens livelihoods and global prosperity.[9]

Furthermore, just when increasing insurance coverage should be a priority, current insurance and risk transfer markets are becoming less effective as tools for pooling and transferring disaster risk. Rising insurance premiums, driven by climate change impacts, are making coverage unaffordable for many households in climate-affected countries such as Australia (see Box 30).[10] Similarly, in the United States, where insurance is often mandatory as part of house mortgage approvals, the average cost of home insurance rose from $1,902 to $2,530 between 2020 and 2023. In postcodes with the highest disaster risk, the increases were much larger, and there is increasing evidence that insurance companies are even withdrawing from what are perceived as high-risk locales.[11]

There is a clear danger that as insurance becomes less affordable, fewer people will buy into it, pushing costs up and leading insurers to withdraw from high-risk markets, although these may be where the needs are most acute. This spiral can have damaging knock-on impacts. For example, property prices may fall as businesses and homeowners cannot get mortgages or other finance in areas considered too high-risk or "uninsurable" (Figure 55). Even where insurance is currently available, the indefinite continuation of this coverage is by no means guaranteed. As policies are usually renewed annually, the price of insurance may rise dramatically or even be withdrawn in the wake of a disaster.

Figure 55. **The unsustainable risk transfer spiral**



Source: GAR original graphic

Furthermore, the increased burden on governments, regarding macroeconomic risks and fiscal spending to cover uninsured losses, may raise countries' debt burdens and increase economic divergence. This spiral hinders financial stability in developed countries. It may impede the development of much-needed risk transfer products suitable for developing countries, where currently only a small fraction of households or businesses can afford disaster-related insurance.

When insurance is unavailable or slow to pay out, businesses and households must absorb losses, slowing economic activity and recovery. When families and firms finance post-disaster recovery with savings, credit or uncertain government relief, recovery is almost always much slower and less efficient.[12] A lack of insurance also poses risks to wider financial stability. In particular, a weak risk transfer market makes investing and accessing loans more difficult and expensive.[13]

Box 31. Australia's affordability-stressed households

According to a recent report by the Actuaries Institute in Australia, the proportion of "affordability-stressed" households, those facing insurance premiums of more than four weeks of gross household income, rose to 15% (more than 1.6 million) in the year to March 2024, up from 12% in 2023 and 10% in 2022. Affordability-stressed households spend an average of 9.6 weeks of their gross income on home insurance, seven times more than non-stressed households.[14]

These soaring premiums are primarily due to increased reinsurance costs in recent years, driven by the rising costs of storms, floods and other hazard events. These escalating risks are caused by climate change, lack of adequate building codes and land planning, and insufficient national risk analyses, among other factors. Decreasing home insurance affordability has added implications for the banking sector, as lenders require borrowers to purchase household insurance. An estimated 5% of Australian households with mortgages, representing A$57 billion of loan balances and 3% of all home loan assets, experience insurance affordability stress.

In this context, governments and financial institutions must work together to develop innovative and sustainable insurance models that make pre-emptive risk reduction a prerequisite for coverage and help households to reduce their risk and remain insurable. For example, the Actuaries Institute has explicitly highlighted that resilience loans could present an opportunity for lenders to assist customers to have safer homes and more affordable insurance.

Aerial urban suburban cityscape landscape view of Perth Western Australia

Credit: Shutterstock, ChameleonsEye

Box 32. The 2025 Los Angeles fires and the $1 billion emergency insurance bailout

The January 2025 Los Angeles wildfires that destroyed over 12,000 structures in some of the most expensive postcodes in the United States exemplify the increasing challenge of insurability in the face of growing disaster risk. California has a long-established public-private insurance scheme to cover homes in commercially unviable, high-risk areas. However, fires in 2017 and 2018 had already wiped out over two decades of profits, leading many companies to start retreating from these areas.

This led more households to resort to the state's own scheme. As of mid-February 2025, claims from this year's fires were estimated to have left a gap of at least $1 billion in the fund. By state law, this must be covered partially from private insurers operating in California (based on their market share) and partially by the state government and customers through future higher premiums.

While authorities are bailing out the affected households, they are also calling for steps to enforce tighter building codes and more extensive risk reduction measures in the recovery. It is still too early to tell whether insurers will continue to operate in the state unless finance models are adjusted and risk reduction efforts can bring risk levels back to an insurable level.[15]

A drone captures structures damaged by the Eaton Fire in Altadena, California, on January 19, 2025

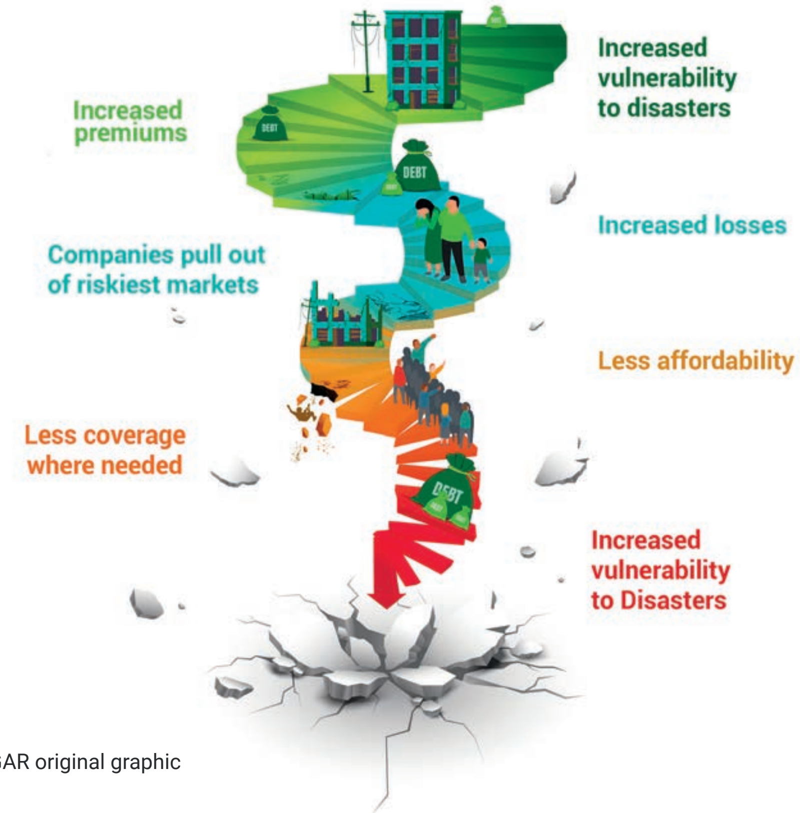
Credit: Shutterstock, Ringo Chiu

Another challenge of current insurance product design is that policies are usually designed only to cover replacement value. Insurers are often reluctant to fund or permit design changes that increase a structure's future disaster resilience. Policies that proactively encourage disaster risk reduction in advance, or offer lower premiums to more resilient assets, are still in their infancy and are not widely available in many jurisdictions. Without more investment in disaster risk reduction, the insurance protection gap is expected to widen due to climate change, which may make insurance unaffordable for many. This is bad for households, businesses and governments who risk covering the costs of helping communities get back on their feet after a disaster.

The respond-repeat spiral

The third negative spiral of disaster risk in financial systems is related to the humanitarian response cycle (Figure 56). Emergency relief in the wake of disasters saves lives but is often expensive and not designed to have a long-term impact on disaster recovery or to address underlying vulnerabilities. Reducing risk or even preventing disasters is a far better investment. Studies show that $1 spent on disaster risk reduction delivers an average return of $15 in averted future disaster recovery costs.[16]

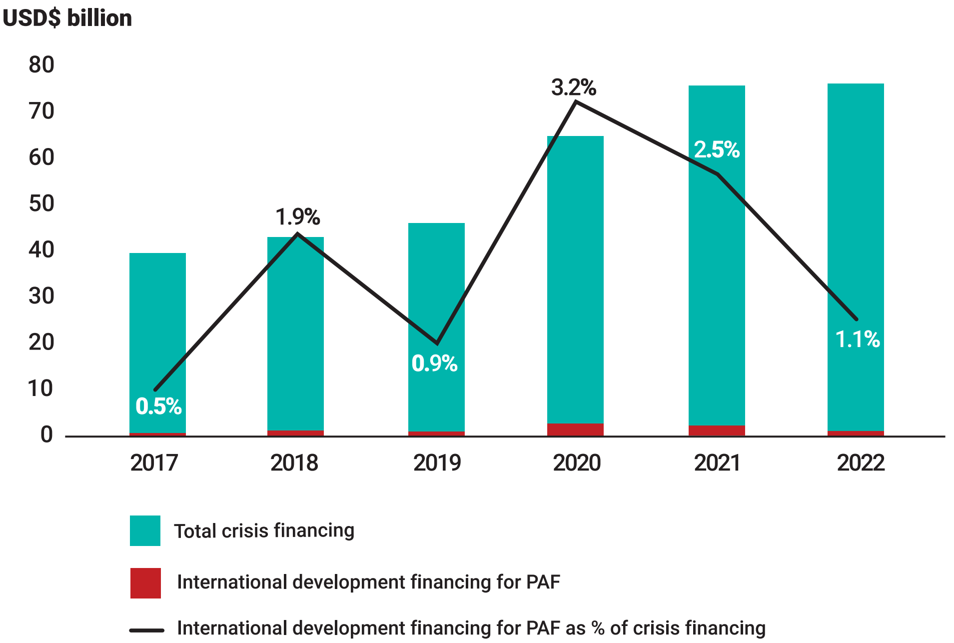
Figure 56. **The unsustainable respond-repeat spiral**



Source: GAR original graphic

Currently, most disaster financing focuses on post-event response and recovery rather than preventative disaster risk reduction, with pre-arranged financing accounting for a very small fraction of crisis funding (Figure 57). This approach perpetuates vulnerabilities and increases long-term costs for recovery and rebuilding.

Figure 57. **International development financing for pre-arranged financing as a proportion of total crisis financing (2017-2022)**

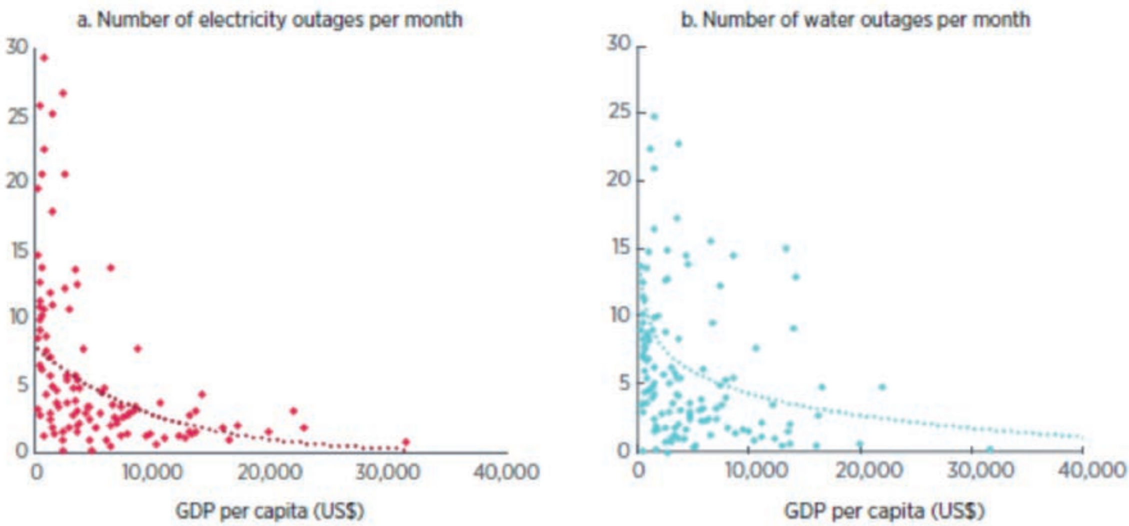


Source: Centre for Disaster Protection, based on data from OECD (2024)

In a high-risk future, relying on post-event responses to cope with more frequent and intense disasters will become increasingly unsustainable. As outlined earlier in this report, when disasters occur repeatedly, households must commit ever-increasing time and resources to recovery. At the national and global level, the consequences of prolonged humanitarian relief operations can contribute to a range of indirect impacts, from protracted economic stagnation and lower investability to increased displacement and social instability. These in turn can have significant consequences at the household level, with women, children and marginalized communities disproportionately affected.

The response-repeat cycle fuels a further pattern where governments spend resources on relief, and insufficient funding is available to invest in basic services and infrastructure. For example, the financial toll of infrastructure disruptions in low- and middle-income countries ranges from $391 billion to $647 billion annually.[17] Impacts are most severe in low-income countries, particularly for the poorest households (Figure 58).

Figure 58. **Infrastructure disruptions hit the poorest countries hardest**



Box 33. Ghana's roadmap for resilient infrastructure in a changing climate

The Government of Ghana and partners recently collaborated on a "Roadmap for Resilient Infrastructure in a Changing Climate." Utilizing state-of-the-art tools and methodologies, it adopted a systems approach to planning infrastructure adaptation. It was the first comprehensive assessment of Ghana's adaptation needs across the energy, water and transport infrastructure sectors. Through an analysis of the financing landscape, the study also helped identify 82 infrastructure-related funds that could be instrumental in achieving its resilience aims.

The process prioritized 35 project concept options that could accelerate adaptation across three main components of the infrastructure system, the built environment, the natural environment and the enabling environment. It also highlighted the co-benefits of these priority resilient investments in accelerating SDG achievement and provided the practical framework for translating climate risk information into action.

The process drew on the expertise of over 119 individuals from 20 ministries, agencies and organizations, which fostered broad ownership of climate adaptation solutions, enhancing the likelihood of successful implementation and climate-resilient outcomes.[18]

High view point hazy cityscape of Accra, Ghana. Traffic jam on George Bush Highway with hills on the background

Credit: Shutterstock, Frank TG Herben

Breaking the spirals: Investment strategies for risk reduction

Pragmatic action taken now to reduce disaster risk can slow and even reverse each of the negative spirals outlined above. However, doing so requires a shift in how governments, financial institutions and the private sector approach investments. Building resilience must be considered during project design and development. It should be an integral part of the management of an asset's lifecycle.

Resilient investments are not only about fiscal preparedness and sustainability. They have the potential to unlock profitable opportunities while addressing the growing risks of disasters. Innovative financing models, regulatory shifts and cutting-edge technologies can provide private investors with ways to achieve returns while reducing disaster risks. Disaster resilience investments, in fact, offer considerable possibilities for innovation. For instance, innovative financial products such as resilience-focused green bonds can align business interests with societal needs, generating returns while addressing the spirals. Embedding resilience features into renewable energy projects ensures stability in operations during extreme weather, aligning private sector profit motives with long-term risk reduction.

Similarly, developing new resilience technologies demonstrates that the private sector can generate healthy returns from disaster risk reduction while helping communities adapt to climate risks. These innovations range from AI-powered analytics to smart grid platforms, sustainable batteries and intelligence-based solutions for agriculture, such as farm robotics and soil monitoring devices.[19] While such solutions may initially be more affordable for middle-income countries, costs can fall as deployment increases. Established and more affordable technologies like rainwater collection and storage present immediate opportunities, too. Just as the price of mobile phones or solar panels has fallen quickly when taken to scale, the same dynamic could help accelerate the uptake of resilient technology.

Combining disaster risk reduction, risk transfer and risk retention tools effectively can help break the three spirals outlined above and deliver instead a triple dividend: stabilized household incomes and sovereign credit ratings, reduced market volatility and expanded economic opportunities for public and private stakeholders.

Breaking Spiral 1: Protecting household income and ensuring more sustainable debt

At the household level

Disasters deplete household savings and, in many cases, increase national debt, leading to economic instability. Firstly, households can take proactive steps to protect their assets and financial stability in advance. Having assessed potential hazards to their homes, assets and pensions to understand their specific vulnerabilities, households can invest in resilience. For instance, by implementing cost-effective improvements in line with local building codes, homes can be made safer by reinforcing structures, improving drainage, or ensuring they are linked to early warning systems.

Where necessary, households can also advocate for stronger community resilience by encouraging local government to invest in resilient infrastructure, improve building codes and make risk analysis more accessible and usable for all residents. In addition, where household budgets allow, they can purchase insurance or join a solidarity group. These actions can provide rapid access to recovery support should a disaster strike, ensuring that households can quickly rebuild and maintain financial stability.

At the national level

Box 34 outlines five steps that governments can take to enhance their disaster risk reduction financing strategies, and to ensure resilience is integral to wider fiscal planning. A number of investment actions that can be tools in this process are described below.

Box 34. Five steps to enhance disaster risk reduction financing

As discussed earlier in this chapter, disaster-related financing has historically been disproportionately focused on post-disaster response and recovery, with relatively little allocated to pre-disaster risk reduction. However, scaling up disaster risk reduction financing is not enough. The development of capacities and mechanisms must accompany it to ensure that resources are applied effectively toward measurable risk reduction outcomes.

Even countries that have committed significant funding for disaster risk reduction, in advanced and emerging economies, have struggled with this challenge. The experiences of Australia and India are instructive in this regard.

In Australia, the Disaster Ready Fund (DRF) is the government's flagship disaster resilience and risk reduction initiative. The government has committed up to one billion Australian dollars through the DRF over five years from 1 July 2023. The fund supports projects that address the physical and social impacts of disasters on communities, including those caused by climate change and other natural hazards.[20]

Similarly, India's National Disaster Risk Management Programme is allocating Indian Rupee (INR) 1.6 trillion (approximately $19 billion) for the period 2021–2026 to strengthen disaster response and mitigation. The funding covers a broad range of priorities, including expanding and modernizing fire services, resettling displaced people affected by erosion, providing assistance to twelve of the most drought-prone states, managing seismic and landslide risks in ten hill states, reducing urban flood risk in the seven most populous cities and implementing mitigation measures to prevent further erosion.[21]

To enable a shift from reactive disaster response to proactive risk reduction, the United Nations Office of Disaster Risk Reduction (UNDRR) has developed a five-step approach. This approach supports countries in better meeting the dual goal of investing in risk reduction and prevention, covering a range of hazards, including seismic and climatic risks, while also managing residual risks and ensuring financial resilience.

The five steps are:

1. **Understanding the financial consequences of disasters,** examining direct losses (from past events and model projections) and indirect costs (economic scarring).
2. **Analyzing the existing Disaster Risk Reduction (DRR) financial landscape,** assessing public finance management systems, private sector regulatory frameworks and international development assistance programs.
3. **Identifying and prioritizing financing needs,** focusing on areas such as resilient infrastructure and agrifood systems and identifying funding gaps.
4. **Matching needs with financing options,** exploring suitable instruments and policies capable of mobilizing public, private and international resources.
5. **Developing a comprehensive DRR finance strategy,** including concrete actions, assigned responsibilities and timelines to enhance DRR financing.

In 2024, UNDRR started implementing this approach across several countries, with promising initial results. For example, in Armenia, finance stakeholders came together and identified opportunities to enhance DRR financing, while in the Seychelles, creating a national DRR financing strategy has helped the country meet required reforms to unlock funding from the IMF Resilience and Sustainability Trust.[22]

Proactive investments in resilient infrastructure, building codes and hazard risk analysis

At the core of disaster risk reduction at the national level is increasing investment in resilient infrastructure, potentially benefiting both household incomes and the private sector. Investments in resilient infrastructure have a four-to-one net benefit in low- to middle-income countries, further doubling when the effects of future climate change are considered.[22] Besides saving lives, resilient infrastructure can reduce the need for post-disaster humanitarian assistance and positively impact ecosystems, with wide-ranging benefits for communities. More consistent access to essential resources, such as clean water, also yields positive impacts on gender equity in societies where water gathering is regarded as a female domestic chore.[23]

Investing in resilient infrastructure is only one part of the solution, however. Effective disaster risk reduction also requires developing and implementing strategies that protect national income and creditworthiness. Relatively low-cost governance actions, such as making risk analysis more accessible and implementing land-use planning improvements and building codes, can incentivize effective resilient investment. Investing now in these approaches can also help create a cadre of national experts able to enhance this work.

Governments can lead by example and require robust hazard risk analysis as part of the approval process for all public investment projects. This can send a strong signal to domestic markets of the importance of planning for future risks. Updating metrics, particularly calculating the cost-benefit of potential projects to account for climate change and other disaster risks, can also encourage smarter investment decisions across sectors.

Debt-for-resilience swaps

Proactive investment to reduce disaster risk requires upfront capital. However, as discussed earlier in this report, while many disaster-prone countries need to invest urgently in resilience, many are burdened by high debt levels, making raising the financing necessary for these investments difficult. Debt-for-resilience swaps can help address this by easing fiscal pressure while directly channelling funds into disaster risk reduction. Unlike green bonds, which require new capital sources, these swaps allow countries to reduce their existing debt in exchange for investments in resilience-building projects. If well designed, these swaps can reduce debt pressure while funding disaster protection, helping households stay financially secure.

For example, in December 2024, Barbados implemented a $165 million debt-for-climate resilience swap, replacing expensive debt with lower-cost loans tied to climate goals. This approach restructured old bonds into new ones linked to environmental performance, ensuring funds were used for climate resilience projects. The swap freed up government funds to fund infrastructure upgrades, including modernizing sewage treatment facilities and improving water management systems to address drought and flooding risks. Effectively, this reduces its debt-to-GDP ratio while securing resources for disaster risk reduction. Barbados demonstrated how financial engineering can align creditor interests with long-term climate resilience goals.[24] Expanding this approach could make debt relief a tool to free up capital for proactive investments, keep economies more stable and improve a country's financial health.

Integrating disaster risks into credit ratings

A recent study by The Indonesian for Energy Economics in Fiji found that strategic investments in proactive measures like early warning systems, community preparedness and hazard-proofing existing housing and infrastructure had helped the country maintain its credit rating despite experiencing high-intensity disasters. This study highlights how incorporating resilience investments into credit rating assessments can positively impact a country's creditworthiness. The study estimated that if disaster protection and resilience investments were incorporated into assessments elsewhere in the region, the average credit rating of the selection of 13 SIDS analyzed in the research would improve from a moderate 6.59 to a higher 7.49 rating.[25]

Integrating disaster risk analysis into credit ratings can incentivize governments to invest in disaster risk reduction, reducing future borrowing costs. To translate this into practice, sovereign credit ratings aim to measure risk and a country's level of investment in resilience and adaptation measures. In doing so, issuers of sovereign ratings could help stimulate increased financial flows towards adaptation and narrow the current $194–366 billion annual adaptation financing gap in developing countries.[26]

Tying credit ratings to resilience efforts penalizes inaction and encourages governments to invest in disaster protection, helping to keep household incomes stable and reduce national debt risks.[27] In addition, central banks can expand their traditional role of maintaining monetary stability to include disaster resilience as a central criterion for financial system stability. For instance, they could demand that commercial banks account for climate and disaster risks in their lending portfolios.

Standards and taxonomies

In addition to mobilizing more private resilience investments, countries must advance clear, universally accepted definitions and classifications for such investments. These standards help investors identify and prioritize projects contributing to disaster risk reduction and climate resilience. Capital market investors struggle to include disaster risks in their capital allocation decisions without such taxonomies. Most jurisdictions still lack the necessary standards and taxonomies on adaptation and resilience finance to support the emergence of innovative financial instruments such as resilience bonds. This lack of conducive regulatory frameworks prevents financial markets from playing a greater role. However, by creating clear standards for resilience investments, governments can give investors more confidence to fund projects that reduce disaster risks.

Policymakers could address this issue by drawing on emerging frameworks, such as the Guide for Adaptation and Resilience Finance, the Climate Bonds Resilience Taxonomy and the Climate Resilience Principles. The latter, co-developed by UNDRR and the Climate Bonds Initiative (CBI), provide a framework for assessing climate resilience investments. The UNDRR and CBI aim to guide the issuance of climate resilience bonds to help investors identify opportunities that enhance climate adaptation and resilience. By focusing on understanding climate risks, addressing systemic barriers to resilience and delivering climate resilience benefits, the framework has been used to certify resilience bonds, including the $700 million Climate Resilience Bond issued by the European Bank for Reconstruction and Development in 2019. This certification process helps ensure that financed projects genuinely contribute to climate resilience efforts.[28]

Similarly, governments can strengthen awareness around their own investments. This is where budget tagging can help (Box 35). Governments can enhance resource allocation and efficiency in public expenditure by labelling, quantifying and tracking public resilience investments in an integrated fashion. It helps them strengthen their awareness of financing gaps, reduce redundancies and channel more funds into the highest impact resilience actions. It also helps understand how disaster risk can be reduced to protect key assets such as state pension funds.

Box 35. Disaster risk reduction and climate change adaptation budget tagging

What gets measured gets managed. Yet, many governments still lack systems to track public spending in disaster risk reduction and climate change adaptation. While at least 60 countries have some experience with conducting ad hoc expenditure reviews, only 32 have taken steps to institutionalize the process through routine budget tagging. In addition, governments often approach disaster risk reduction and climate change adaptation as separate issues, despite the significant overlap between them, leading to inefficiencies.

To address these issues, governments can quantify and track public expenses in these areas by adopting a tagging system that identifies, classifies and marks relevant expenditures in a government's budget system, enabling the estimation, monitoring and tracking of those expenditures. Tools like UNDRR's disaster risk reduction and climate change adaptation budget tagging guide help government officials design budget tagging initiatives. Countries are already using this guidance. For example, in Kenya and Madagascar, UNDRR helped governments to set up such a system to mainstream disaster risk reduction and climate change adaptation into sectoral budgets. Moreover, tracking expenditure over time allows for more accountable, evidence-based decision-making, offering critical insights into spending patterns and performance.[29]

At the private sector level

The previous sections described how proactive investments at the household and national levels, combined with changes in the financial systems, can help break Spiral 1. Disaster risk reduction investments from the private sector can further strengthen these elements. Analogous to households, businesses can begin by identifying potential hazards to their operations and supply chains before taking steps to make both more resilient. To support these efforts, various innovative financing tools can help attract private investments for disaster risk reduction, helping businesses prepare for climate shocks. Beyond protecting businesses, these investments also benefit communities and countries as a whole. The following sections will explore these tools in detail.

Green bonds with resilience components

Green bonds can mobilize private capital for disaster risk reduction while stabilizing long-term economic growth. The market for green bonds is growing exponentially and is estimated at approximately $1.05 trillion in 2024.[30] These bonds mainly finance renewable energy and other low-carbon projects.[31] By allocating a portion of their funding to resilience measures, green project bonds can appeal to investors by enhancing project stability and lowering repayment risks while providing community benefits. For example, the investment in the restoration of mangroves surrounding a financed wind power project in Pakistan could potentially offer a return 20 times the value by protecting physical assets against coastal erosion, saving the project developer and its investors up to $7 million over the project's 25-year timeframe, while doubling the income of local communities.[32]

Progress in this area, though still modest, is nevertheless positive. A recent analysis identified over 900 green bonds issued to date that include climate resilience components, indicating a small but growing trend in integrating resilience into green financing.[33] These investments must now be scaled up. One significant barrier, however, is the lack of data and commonly agreed criteria for resilience investments.[34] Improving risk understanding and probabilistic risk assessments can help plug this gap, particularly when they are aligned with tools like the Climate Bonds Resilience Taxonomy to help investors identify good resilience investments.[35]

Concessional blended finance models can be employed to address the additional costs of implementing some resilience features, at least initially. Blended finance in this context refers to the strategic use of development finance to mobilize additional funding for sustainable development in developing countries.[36] It can make marginal projects more resilient and viable, encouraging more investors to adopt these features in future projects on purely commercial terms.[37] (This is explained in more detail in the next section.) In addition, incorporating flexible repayment terms in resilience bonds, such as allowing temporary deferrals after a disaster, can further balance the needs of borrowers and investors.

If the mentioned limitations can be addressed, such "dual-purpose" green bonds (combining low-carbon and resilience investments) could offer a powerful way to tap into the rapidly growing green bonds market, leveraging its scale to advance disaster resilience. The following examples show how green bonds are already deployed to strengthen infrastructure disaster resilience while supporting economic stability.

- In the Philippines, the Energy Development Corporation (EDC) enhanced the resilience of its geothermal energy operations by implementing infrastructure upgrades and disaster response measures. To finance these projects, the International Finance Corporation issued the first triple-A Philippine peso-denominated green bond in 2018, alongside EDC's Association of South-East Asian Nations' (ASEAN) Green Bonds in 2021. These instruments raised significant funds, with $14 million allocated to calamity resilience. The measures stabilized EDC's insurance premiums in a market where rates are otherwise rising, highlighting how green bonds can help create an environment for steady insurance rates.[38]

- In the United States, voters in Miami approved the $400 million Miami Forever Bond in 2017 to fund critical infrastructure projects, including sea-level rise prevention and urban green spaces. This General Obligation Bond allows the city to finance major improvements without raising taxes, as it is backed by the city's credit. The bond allocates $192 million for sea-level rise mitigation and flood prevention, aiming to protect critical infrastructure and reduce economic vulnerability. This mechanism demonstrates how cities can use green bonds to enhance disaster resilience through strategic infrastructure investments.[39]

- Singapore's Green Plan 2030 also catalysed significant green finance. In 2022, the government announced plans to issue $35 billion in green bonds by 2030 to fund public sector green infrastructure projects. This move aims to strengthen Singapore's climate engagement while promoting economic stability and the bonds finance projects in renewable energy and sustainable water management, among others.[40]

Another type of bond, commonly called a "catastrophe bond", helps provide countries with critical disaster insurance protection. It is discussed in more detail later.

Concessional and blended finance

While green bonds and other innovative financing tools can make a critical contribution to scaling up disaster risk reduction, resilience investments may lack sufficient returns for profit-driven investors. In addition, higher risks and up-front costs in developing countries can make some investments unattractive, particularly if the long-term nature of these resilience investments does not align with typical private sector timeframes.

Blended finance can help address some of these challenges. By combining private investments with concessional public funds, some risks and costs can be absorbed, enhancing the risk-return profile. It can thereby make disaster risk reduction investments more attractive. A concessional finance provider (a development finance institution, for instance) can agree to absorb a portion of the initial losses, meaning that if a project loses money, the concessional capital absorbs the first portion, reducing risks for commercial investors. Concessional capital can also extend loan tenors, provide patient capital or offer revenue-sharing models, making it financially more feasible for private investors to commit to longer-term resilience projects that may have delayed returns but generate sustained impact.

One prominent example of a blended finance model is the $1.5 billion Project Gaia, which demonstrates how blended finance can apply to climate resilience in developing countries.[41] The platform provides long-term loans for climate change adaptation in vulnerable regions, including for access to water and disaster resilience. Its capital structure includes a $152 million junior equity tranche from the Green Climate Fund, $1.35 billion in senior debt from private investors and a Technical Assistance Facility to support projects and disseminate best practices. The junior equity tranche absorbs first losses, effectively de-risking investments for private investors. This layered structure enables Project Gaia to mobilize significant private capital for climate resilience, demonstrating how blended finance can leverage public funds to attract private investment in high-risk, high-impact areas.[42]

While blended finance is increasingly seen as a key tool, it typically relies on concessional funding to buffer investment risks. As this tends to come predominantly from governments or donors, expanding blended finance to meet the growing demand for large-scale investments can present challenges. To address this limitation, other financial innovations, such as the Infrastructure Resilience Development Blueprint, are being piloted to enable resilience investments in complex markets on more commercial terms(Box 36).

Box 36. Leveraging finance in high-risk markets: The Infrastructure Resilience Development Blueprint

The financing of many infrastructure projects often requires projects to be insured so that banks can be sure of repayments, even if the project is disrupted during construction by a disaster. However, finding insurance is sometimes a bottleneck, with some projects being shelved because they could not access appropriate cover. This is a particular challenge in developing countries with insufficient risk data coverage and low insurance penetration. At the same time, the insurance industry is a major investor actively seeking projects that can meet its credit quality requirements, ensuring they are resilient to future shocks.

Recognizing this market opportunity, the Insurance Development Forum, in collaboration with BlackRock, recently announced a new investment strategy to mobilize insurance capital into small to mid-size commercial infrastructure projects in developing and emerging markets. The strategy's ultimate objective is to provide a replicable, scalable solution for insurance companies to invest in resilient infrastructure projects to improve the resilience of vulnerable communities. Investments will be made through senior and mezzanine secured debt with a credit profile that is compatible with the requirements of the global insurance industry.

Carbon projects with resilience co-benefits

Carbon finance with resilience co-benefits offers another promising avenue to attract private capital for disaster risk reduction investments. In 2023, the value of traded carbon credits was approximately $723 million. While this reflects a contraction from previous years,[43] the market is projected to reach an annual value of $10–40 billion by 2030,[44] driven by companies aiming for net-zero emissions. Carbon trading rules agreed at the 2024 Climate COP could further bolster demand.[45]

Carbon finance can potentially complement green bonds, blended finance and innovative risk management models by addressing their specific limitations. Green bonds often require large-scale projects due to high minimum issuance sizes, making them less suitable for smaller initiatives, while carbon finance can directly support localized projects. Blended finance depends on limited concessional funding, which restricts scalability, whereas carbon finance attracts private capital through the growing demand for premium-priced carbon credits. Additionally, carbon finance can increase the internal rate of return for projects that might otherwise be unattractive to investors, helping to overcome investability barriers. It can scale disaster risk reduction efforts where other tools may fall short.

Projects like mangrove restoration, agroforestry and agricultural water management can generate significant revenues by selling carbon credits in the carbon markets. Beyond reducing emissions, these projects can deliver risk reduction co-benefits, such as storm surge protection, soil conservation and drought resilience, in developing countries. The latest data shows that projects generating co-benefits receive a massive 78% premium over average carbon credit prices, as buyers increasingly look for such projects to bolster their reputation and Corporate Social Responsibility profile.[46]

To maximize disaster resilience benefits for households and local economies, however, carbon projects must be designed with strong community engagement. They must ensure that local stakeholders have a meaningful voice in project development and benefit sharing while effectively reducing local disaster risks. One example of this approach is the Boomitra Soil Carbon Sequestration Initiative. By generating returns from the sale of carbon credits, it collaborates with smallholder farmers in the Global South to implement sustainable agricultural practices that enhance soil carbon storage. The practices improve soil fertility and water retention, strengthening resilience against slow-onset disasters like droughts and erratic rainfall while ensuring long-term agricultural productivity. The initiative received the Earthshot Prize in 2023 for its climate benefits and has attracted $4 million in investments from major companies.[47]

Another area where projects combine low-carbon and resilient investments is in innovative renewable energy, particularly off-grid solar photovoltaic (PV) systems with "black start" capabilities that mean they can function even when the rest of the grid has been shut down due to damage after a major storm or other disaster. These systems can generate carbon credits from emission reductions while providing reliable energy during disaster-induced grid outages. There could be interesting opportunities here to link risk reduction cost savings with lower risk transfer costs. For example, such energy projects could present a business opportunity for insurers. By financing these systems for their insured customers, investors could tap into multiple revenue streams, earning interest on the loans they give out while benefiting from carbon credit revenues. There are, however, some practical limitations to this approach. Because communities in disaster-prone or remote areas are often in lower-income areas, the substantial upfront installation costs of off-grid PV systems with black start capabilities may deter clients and insurers. Nevertheless, securing up-front carbon funding could overcome this hurdle.

These examples show how carbon finance, if designed well, can complement other financing tools and attract additional private capital, benefiting households at a community level, reducing local economic volatility and diversifying funding sources for resilience.

Corporate climate-risk disclosures driving private sector investment

For companies, staying investable in an era of increasing climate-related risks is paramount. To maintain access to financing and investor confidence, businesses will increasingly have to disclose their exposure to climate risks and demonstrate proactive measures to mitigate them. Companies that fail to invest in pre-emptive risk-reduction measures risk being perceived as less resilient and more vulnerable, deterring investors seeking stable, long-term returns.

Climate-risk disclosures are at the heart of this shift. European Union instruments such as the Corporate Sustainability Reporting Directive and the Corporate Sustainability Due Diligence Directive, as well as voluntary frameworks like the Climate Disclosure Project, the Task Force on Climate-Related Financial Disclosures and other emerging frameworks, increasingly require businesses to disclose their exposure to climate-related risks, including the physical impacts of disasters,[48] and even create due diligence plans to address these risks.[49]

As investors gradually prioritize climate-resilient portfolios, companies that fail to invest in pre-emptive risk-reduction measures may risk higher financing costs, divestment, and reputational damage.[50] This risk incentivizes businesses to invest in resilience. Investors themselves are also under growing pressure to disclose their climate risks. More than 40 countries now require large financial institutions to report how climate risks could affect their investment portfolios.[51] These institutions are also starting to factor in the impact of climate disasters when valuing assets, pushing companies to take action to protect their investments.

Businesses meet regulatory demands and secure broader access to financing and investor confidence by addressing climate risks, creating a financial incentive for corporate risk-reduction investments. Expanding climate-risk disclosures and embedding resilience metrics into disclosure frameworks will further drive this shift.

At the global level

Finally, this section examines how international development finance institutions (DFIs) can support resilience investments.

Expanding the role of development finance in resilience funding

At the global level, DFIs can play a crucial role in accelerating the investments described earlier in this chapter, both at the household, national and private sector levels. DFIs can achieve this through several strategies:

- **Prioritizing resilience in funding criteria:** DFIs should require that projects they fund address climate risks by setting clear resilience criteria during the project design phase. Where they provide loans to countries, DFIs can encourage borrowing countries to demonstrate how loan proceeds will enhance resilience in the countries' infrastructure, agriculture and social programs. By setting such precise requirements for funding, they can also cover remaining gaps in national resilience standards and showcase criteria that governments can use to strengthen their own national resilience taxonomies. DFIs can also lead international efforts to promote common standards for measuring and classifying resilience investments. This enhances transparency, facilitates private capital mobilization and enables effective monitoring of resilience-building efforts.

- **Incorporating flexible repayment terms in DFI loans:** When a country is hit by a disaster, DFIs can give them some breathing room on their loan payments. For instance, given the frequency and destruction caused by extreme weather events in the Caribbean, the Inter-American Development Bank (IDB) has introduced the so-called "hurricane clause," which also considers similar disaster-linked clauses in its loan agreements. The hurricane clause is designed to provide cash flow relief at the crucial period after a natural hazard-related disaster event, when financing needs are high and new funding sources are limited. Under the conditions of the loans, a country hit by a predefined disaster can defer principal payments for two years. When well-managed, such clauses can offer crucial relief and support economic stability in times of turmoil.[52]

- **Offering concessional financing:** By providing favourable terms and guarantees through concessional financing, for example, DFIs can unlock investment by de-risking resilience projects. DFIs can also facilitate debt-for-nature or debt-for-resilience swaps to help free up countries' fiscal space for resilience investments and facilitate resilience-related bonds and similar financial instruments. They can do so through research, technical assistance and pilot projects. For instance, in 2015, the Seychelles converted $21.6 million of national debt into coastal and marine conservation funding. The freed-up fiscal space and demonstrated commitment to conservation enabled the Seychelles to issue a blue bond, supported by a guarantee and technical assistance from the World Bank. Both mechanisms funded coastal management and marine protection, enhancing the country's resilience to climate-related disasters like storms and sea-level rise.[53] While debt swaps have remained a relatively niche instrument, this may be changing with Belize, Ecuador, Gabon and El Salvador all signing swaps for over $500 million since 2021, and other countries such as Eswatini, Gambia, Kenya and Sri Lanka also considering debt swap deals.[54]

- **Raising awareness about successful resilience projects:** Private sector investors can be wary of resilience projects in cases where they do not yet have experience with the expected risks and returns of such projects. By actively promoting successful resilience projects and communicating transparently about the factors leading to success and challenges, DFIs can enhance understanding of resilience investments and reduce the perception of risks, thereby enhancing the confidence of private investors to engage.

- **Providing technical assistance:** DFIs can offer technical support to countries in designing comprehensive, layered risk financing strategies. Many developing nations lack expertise in creating effective strategies that combine risk reduction, transfer and retention.

Overall, the multi-level approach, discussed in these sections, reduces potential losses through proactive investments, incentivizes resilience investments through innovative funding, and embeds resilience into global finance through systematic changes. By implementing this comprehensive strategy, countries can effectively break the cycle of decreasing income and increasing debt caused by disasters, while building long-term economic resilience.

Breaking Spiral 2: Fixing risk-transfer finance

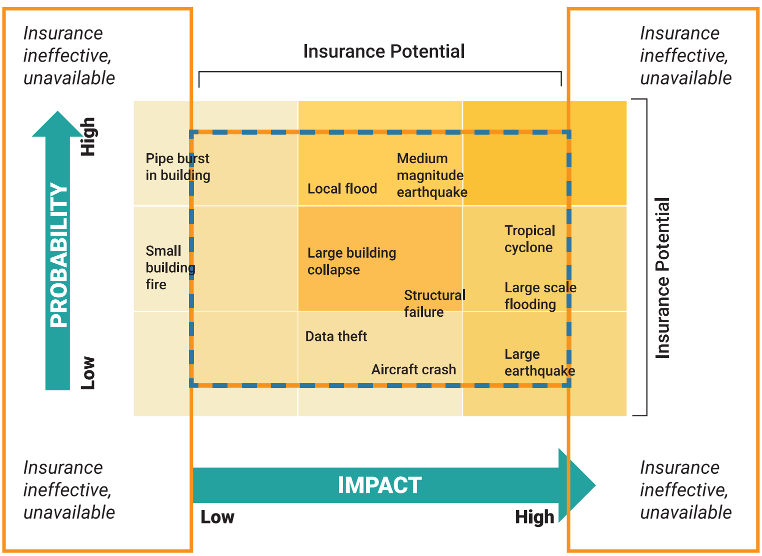
Risk transfer is about more than insurance: in its simplest form, it formally or informally shifts the financial consequences of particular risks from one party to another in exchange for ongoing or compensatory social or financial benefits.[55] In a riskier future, finding innovative ways to share risk and scale up insurance will be key to a less volatile and sustainable future. In particular, policymakers must put in place more comprehensive and sophisticated tools to deal with extreme weather events and minimize future costs to taxpayers, who otherwise may cover the costs of major disasters if insurance companies pull out of high-risk areas.

To fix insurance finance, coverage and insurance premiums must be more accessible and predictable. Accessible and predictable insurance requires better incentives for pre-emptive risk reduction and fostering innovation to share or pool risk broadly and maintain long-term coverage. It also requires making judicious decisions about when to retain some risk and implementing anticipatory plans to cover unavoidable costs as and when they occur.

Where disaster risk cannot be reduced in advance, risk transfer financing strategies can be effective. Tools like insurance can spread the risk of a disaster event and reduce the burden on households or governments. Well-designed insurance methods that cover a percentage of GDP losses can reduce financial volatility and stabilize public finances. Such mechanisms can be especially effective in small island states, where a single storm can wipe out an entire year's GDP, as outlined above.

Mechanisms must be designed to fill this gap optimally. Insurance works best for mid-range risks and is less effective at covering events with high levels of either probability or impact (Figure 59). Where economic losses are too small, tools like humanitarian relief are more effective and have lower transaction costs. In many locations, small-scale community savings groups or unofficial micro-credit entities provide some risk transfer cover. Where economic losses are too large, on the other hand, there is a risk that insurers will withdraw or go bankrupt. In most cases, this could be addressed through reinsurance, which can spread risk even more broadly across the global financing system.

Figure 59. Effective and ineffective insurance options



Source: World Bank, "Financial Protection for Public Assets" 2021 International Bank for Reconstruction and Development / International Development Association or The World Bank, 1818 H Street NW, Washington, DC 20433

At the household level

For those who can afford it, private insurance is a vital first line of defence to cover disaster losses. Insurance is usually most effective for households able to pay the premiums without sacrificing other core expenditures. It is therefore not a substitute for life-saving humanitarian relief for the poorest households. Instead, it can be a powerful tool in helping households emerging from poverty to protect and grow their assets. Where formal insurance is unavailable or unaffordable, local programs like women's savings groups and community solidarity funds can sometimes provide similar protection. These alternatives help bridge the gap between formal insurance and no protection.

Increasing the rate of household insurance, through both formal and informal means, can reduce the burden on public finances after a disaster. To boost coverage, policymakers can implement measures such as opt-out schemes for common hazards like floods or link coverage to mandated social insurance schemes. These approaches can help create a more comprehensive safety net for at-risk communities.

However, insurance often faces pricing challenges that make it less effective for developing countries and LDCs in particular, sometimes leaving out communities that may need it most. Where fiscal space allows, policymakers should incentivize the development of affordable insurance products for vulnerable populations, for example, through tax exemptions on disaster-related insurance products, subsidized premiums and public-private partnerships. In Fiji, for instance, the government granted a VAT exemption in 2021 on premiums for climate and disaster risk parametric insurance products. This policy aimed to make such insurance more affordable for vulnerable populations, including farmers and fishers, enhancing their financial resilience against natural hazard-related disasters.[56]

By incentivizing affordable and accessible insurance products (Box 37), ensuring timely payouts and fostering risk mitigation, among other mentioned factors, countries can break Spiral 2 dynamics at the household level.

Box 37. Principles for effective disaster risk insurance

Insurance should encourage disaster risk reduction as a tool for adaptation and reducing vulnerability to climate-related catastrophes over time. Currently underdeveloped, insurance policies can promote risk reduction and adaptation through thoughtful design, while limiting moral hazard (for example, via impact underwriting). Beyond affordability, for an insurance or other risk transfer product to be effective, as part of the risk reduction approach, it should provide the following elements:

1. Incentivize households to reduce disaster risk in advance.
2. Complement existing insurance coverage mechanisms.
3. Ensure timely payouts after a disaster.
4. Provide multiple-year coverage and help households rebuild stronger after a disaster, making them better prepared for future risks.
5. Share costs and responsibilities across the relevant stakeholders to ensure “skin in the game” and reduce moral hazard.
6. Lower public sector losses from major disasters over the long term.[57]

At the private sector level

At the private sector level, risk transfer is a vital element of managing disaster risk. However, companies should not rush to buy insurance without first considering how to reduce and share risk across their products and supply chains. Businesses should assess their vulnerabilities, diversify suppliers and adapt operations to minimize exposure before making the decision to invest in transferring some of their residual risks to insurance. Well-designed policies can incentivize proactive risk reduction, ensure timely payouts and support rebuilding stronger after disasters. By integrating these strategies, businesses can protect assets, maintain operations and contribute to broader economic resilience.

At the national level

Household insurance is essential, but relying solely on it may not be enough to cover the large-scale financial impact of extreme events. Governments also need to think about how they can better transfer risk. One common approach has been public-private partnerships (PPPs), which can make insurance more accessible and affordable at the national level. However, given the increasing scale of climate-related disasters, traditional PPP models face challenges that require further evolution.

Public-private partnerships: Strengths and challenges for disaster risk reduction

PPPs at the national level have been a powerful tool expanding access to insurance, making coverage more affordable and financially sustainable. While government insurance programs provide quick recovery funds after disasters, PPPs enhance their effectiveness by involving private sector expertise in risk assessment, underwriting, and claims processing. Also, by sharing risks between public and private sectors, PPPs help prevent market collapse, reduce reliance on government budgets and ensure that insurance markets remain solvent even after major disasters.

The private sector contributes risk assessment, underwriting, and rapid claims processing in a typical PPP model. In contrast, the public sector is a reinsurer of last resort, aiming to ensure stability and prevent market collapse. However, PPPs can face several challenges:

- **Sustainability concerns:** With the increasing frequency and intensity of disasters due to climate change, the public sector acting as a reinsurer of last resort may become unsustainable, potentially draining public budgets.
- **Moral hazard:** If governments guarantee all losses, there is less incentive for risk reduction
- **Efficiency issues:** Public funds are sometimes allocated reactively, rather than proactively, for risk prevention.[58]

To address these challenges, some governments have introduced mandatory coverage (requiring individuals to insure against catastrophes) or mandatory offers (requiring insurers to include catastrophe cover in property insurance).[59] However, these measures alone may not be sufficient. There is a growing recognition that PPPs must evolve to encourage private sector innovation in risk assessment and transfer mechanisms. Furthermore, there is a need to develop more sustainable risk-sharing arrangements that do not overburden public finances. By evolving in these ways, PPPs can support the development of more resilient and sustainable insurance systems that withstand the increasing pressures of disasters without over-relying on public funds.

Evolving beyond PPPs: comprehensive national-level strategies

Beyond PPPs, governments can adopt sovereign risk insurance policies to ensure a rapid financial response to disasters. They can become even more cost-effective when designed to incentivize proactive risk reduction, leading to lower premiums as expected payouts decrease. To achieve this, however, strategic prioritization is essential, especially in resource-constrained countries. Instead of insuring all public assets, governments can prioritize critical infrastructure such as healthcare, transportation and energy.[60] This approach ensures that essential services can be restored quickly after disasters, minimizing long-term economic disruption.

Morocco's two-pillar catastrophe insurance system highlights how national-level insurance can mitigate economic losses from disasters. When a magnitude 6.8 earthquake struck western Morocco in September 2023, over 1 million people were directly exposed. Economic losses were estimated at up to 8% of Morocco's GDP. Thanks to its pre-financed disaster risk mechanism, however, the government swiftly disbursed $275 million using pre-agreed parametric criteria.[61] Importantly, the government's system provided comprehensive coverage to people holding private insurance contracts through its National Catastrophe Insurance Pool. It also provided coverage for those unable to afford premiums through a government-backed Solidarity Fund. This approach enabled swift reconstruction efforts while reducing the financial strain on the government.

Nevertheless, for national-level risk insurance to work, it requires accurate risk data and reporting to price insurance appropriately; strong governance and financial oversight to ensure transparency; and standardized risk assessments to prevent mispricing and financial vulnerability. Morocco's experience shows that when designed effectively, with accurate risk data, targeted coverage of critical assets, and transparent governance, national-level insurance can reduce financial strain, improve recovery times and make insurance more accessible.

Despite these benefits, even well-structured sovereign insurance may not be sufficient in extreme disasters, particularly when risks exceed the financial capacities of governments and insurers. This is where catastrophe bonds come into play.

Catastrophe bonds

In cases where national-level insurance and PPPs may not be enough to handle growing risk, or when government budgets and traditional reinsurers lack the capacity to absorb large-scale disasters, catastrophe bonds offer an alternative solution. First, governments or insurers issue bonds sold in financial markets to large-scale investors, hedge funds or pension funds. If no disaster occurs, investors receive a fixed rate of return on their investment. On the other hand, if a disaster does happen, a payout from the investors to the government or insurance company is made, while the obligation to pay interest and repay the principal to the investor is either delayed or completely forgiven.

Catastrophe bonds transfer risk to global investors and provide additional financial protection beyond traditional insurance. They can also reduce the financial strain on governments or insurers and make funding more reliable, thereby creating a stronger and more affordable system to manage extreme events that exceed the limits of traditional insurance.[62] By reducing the burden on governments and insurers, catastrophe bonds can also contribute to keeping insurance premiums more affordable and create a more accessible and resilient financial safety net for countries.[63] Jamaica, for instance, made history in 2021 when it became the first island state to independently secure a catastrophe bond. Issued through the World Bank's International Bank for Reconstruction and Development, with funding from 15 global investors, it provided $185 million in financial protection against major hurricanes. This critical disaster insurance coverage was extended in 2023 for an additional four hurricane seasons.

Umbrella stop-loss insurance

While national insurance schemes, PPPs and catastrophe bonds help expand access to disaster coverage at the national level, insuring 100% of potential losses may be prohibitively expensive for the governments and their partners. This is especially true for LDCs and SIDS, where disaster losses can represent a significant share of GDP. So-called "umbrella stop-loss insurance" can address this challenge. It caps financial exposure at a predefined threshold, helping ensure that insurers and governments remain solvent even when major disasters strike. Once losses exceed this limit, external insurers absorb the excess.

This mechanism stabilizes the market and prevents insurance disruptions after major disasters. Instead of attempting to cover all damages, a stop-loss policy might only cover specific priority sectors in a country (such as healthcare or essential infrastructure) and provide a cash payout relative to GDP losses to ensure that governments can support recovery, even if not all losses are recouped. Primary conditions for success include:

- **Clear risk thresholds:** To ensure financial predictability, it is important to define when exactly coverage applies.
- **Complementarity to insurance markets:** The policy should support, rather than replace, private insurance.
- **Risk reduction incentives:** Similar to insurance at the household level, the policy should encourage investment in disaster prevention.

To create a sustainable and accessible disaster risk transfer system, governments can consider a layered risk financing strategy incorporating a range of mechanisms that improve affordability and market stability (such as national insurance schemes and PPPs), provide additional financial security by tapping into global capital markets (innovative finance mechanisms like catastrophe bonds) and ensure that major disasters do not overwhelm public and private insurance systems (tools such as umbrella stop-loss insurance). By combining these elements, governments can reduce financial risks and promote resilience.

At the global level

Regional and global partnerships can further complement household and national-level insurance by spreading risk across multiple countries, making insurance more affordable, reliable and accessible, especially for large-scale, infrequent disasters that are difficult for individual nations to handle alone. While the national-level solutions discussed earlier help protect individual countries from financial collapse, regional and global partnerships take this further by:

- Pooling resources across multiple nations to reduce the financial burden on any single country.
- Ensuring faster payouts after disasters by having pre-agreed funding mechanisms.
- Making insurance more affordable for countries that might otherwise struggle to secure coverage.
- Encouraging risk reduction through shared expertise and collective disaster management strategies.

This can reduce the risk for individual countries and further enhance the accessibility of insurance.[64]

Major regional parametric risk pools, such as the Caribbean Catastrophe Risk Insurance Facility (CCRIF), African Risk Capacity (ARC) (Box 38) and the South-east Asia Disaster Risk Insurance Facility (SEADRIF), exemplify this collaborative approach.[65] By working together, countries can enhance financial resilience and reduce individual risks, creating a stronger, more inclusive safety net for all.

In conclusion, countries can spread costs and lower premiums, making coverage more accessible and affordable by combining household insurance incentives and national-level risk financing tools. Regional and global partnerships further expand this risk-sharing, helping high-risk areas secure more affordable disaster protection where individual countries may fall short. Together, these layers can help break Spiral 2.

Box 38. **The African Risk Capacity Insurance Mechanism**

The ARC, a specialized agency of the African Union, provides parametric insurance to member states. Despite challenges in its earlier phase (in 2015, an anticipated payout in Malawi was not triggered due to discrepancies between the insurance model's parameters and the actual crops planted by farmers), ARC's framework has facilitated the development of disaster risk financing strategies across Africa, promoting resilience through innovative insurance solutions. Illustrating this progress, after a record-breaking drought in Malawi in 2024, the agency delivered $11.6 million in direct relief payments to hundreds of thousands of households.[66]

Over the last two decades, Africa experienced the highest number of deaths from drought

Credit: Creative Commons: Oxfam East Africa.

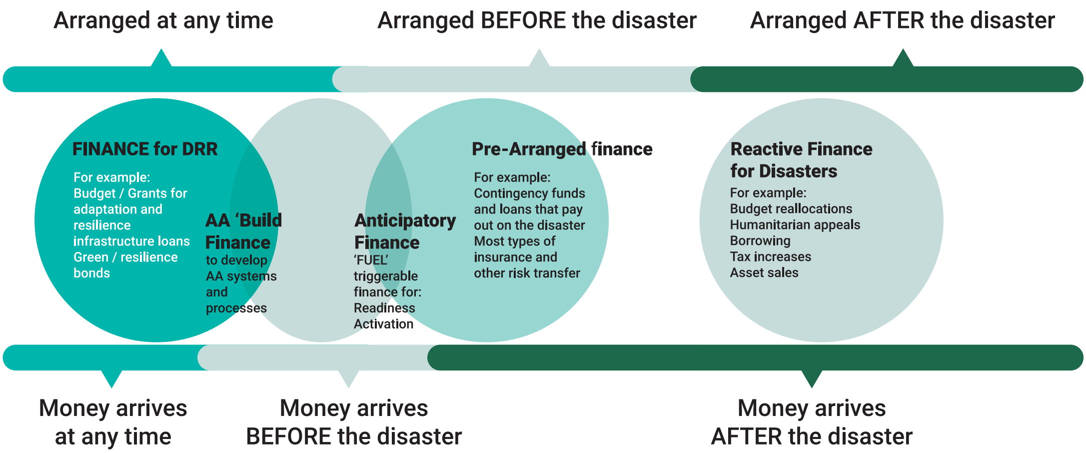
Breaking Spiral 3: Preventing the response-repeat spiral

The spiral of disaster response and recovery traps countries in a pattern of rising costs, economic setbacks and repeated shocks. To break this cycle, the most obvious first step is to reduce as much as possible the amount of "residual" risk that can lead to a humanitarian crisis. This means investing in understanding where people and assets are more vulnerable and exposed ahead of disasters, reducing risk in advance and extending access to life-saving early warning systems.

As outlined at the recent World Crisis & Emergency Management Summit 2025, embracing cutting-edge technologies, such as artificial intelligence and digital platforms, can supplement local knowledge and enhance the effectiveness of emergency and crisis management planning and tools.[67]

The timing of investment is key to preventing the escalation of hazards into a humanitarian crisis. Investment in advance is more effective, which must be reflected in the investment sequencing. Figure 60 shows the timescales when disaster-related finance is best deployed, from preparedness to emergency relief.

Figure 60. **Types of finance deployed across the disaster management cycle**



Source: Adapted from UNDRR, Anticipatory Finance: An Introductory Guide (2024)

This chart underscores that where risks cannot be prevented, the key to breaking the response-repeat spiral is to shift as much as possible to pre-arranged funding and designing interventions to accelerate recovery. This minimizes the time that households and businesses must rely on handouts. Interventions should also aim to "build back better" and prevent future losses and economic setbacks, rather than merely restoring the status quo. Disaster preparedness actions that can be taken in advance that can reduce the scale of required emergency response include:

- **Planning:** Households can create emergency funds while participating in community preparedness.
- **Ensuring continuity:** Businesses can develop business continuity strategies to maintain operations during disasters.
- **Strengthening social protection systems:** Well-designed national social safety nets can prevent vulnerable households from falling deeper into poverty after disasters.
- **Structural economic measures:** Economic diversification and expanded social protections for all workers, especially in countries with high labour informality, can help communities better withstand disasters.
- **Pre-arranged funding for early action:** National and international financial mechanisms can ensure rapid access to resources before and immediately after disasters, reducing long-term economic damage.

At the household level

Households can move from simply reacting to disasters to proactively reducing risks by planning and building financial resilience. This includes creating individual emergency savings and community solidarity funds for emergency needs.[68] Households can also participate in community preparedness programs and learn about local disaster risks, response options and contingency plans. Governments can support these efforts by establishing social safety nets that provide temporary support after disasters. By fostering a culture of preparedness and ensuring timely support, households can reduce their reliance on emergency aid and recover more quickly when disasters strike.

At the private sector level

Businesses cannot eliminate all disaster risks, but they can take steps to buffer against them. Rather than simply reacting to disasters, businesses can develop business continuity plans that identify potential risks and outline strategies to maintain operations during disasters. Companies can also collaborate with governments and communities to advocate for stronger disaster risk reduction measures, such as improved infrastructure or early warning systems. By buffering against unavoidable disasters in this way, businesses not only protect their operations but can also contribute to broader community resilience, reducing the overall need for emergency response. Beyond their own operations, businesses also have the potential to support broad resilience aims by committing funds to Corporate Social Responsibility (CSR) investments, including disaster risk reduction (Box 39).

Box 39. Corporate social responsibility and resilience investment in India

In 2014, India made history by becoming the first country to legally mandate CSR through Section 135 of the Companies Act, 2013.[69] This requirement applies to companies that have (i) an annual turnover of ₹10 billion ($134 million) or more, (ii) a net worth of ₹5 billion ($67 million) or more, or (iii) a net profit of ₹50 million ($673,000) or more in the previous financial year. Companies that meet the above criteria must spend a minimum of 2% of their average profits from the previous three years to fund CSR initiatives outlined in Schedule VII of the Companies Act.

As a result of this legislation, the private sector became much more active in post-disaster risk finance and CSR. There are also signs that the legislation is fostering greater private sector attention to disaster risk reduction more generally. For example, the Tata Group proactively revised its CSR guidelines[70] to ensure that disaster risk reduction principles are integrated across all its CSR activities.[71]

Corporate Social Responsibility Health initiative Karnataka - Outreach Health Program

Credit: tcfindia

At the national level

Scaling local and national social protection systems

Building on this foundation of household and business preparedness, governments play a crucial role in scaling up support at the national level. Many disaster-prone communities already access financial support mechanisms, such as solidarity funds for emergency needs, to help families rebuild.[72] Governments can strengthen these efforts through robust social protection programs, financially assisting vulnerable populations and stabilizing household incomes during crises. For these programs to build effective disaster resilience, they should be:

- **Flexible and scalable:** Able to quickly expand coverage after disasters.
- **Predictably funded:** Supported by stable sources like government budgets, social security contributions and contingency funds.
- **Consistently supportive:** Offering long-term aid to help people withstand economic shocks.
- **Disaster-resilient:** Disaster risk reduction needs to be explicitly embedded in social protection
- **Comprehensive:** A clear strategy is in place.

By strengthening social protection systems, governments reduce the financial strain on households, preventing disasters from leading to long-term poverty.

Rethinking disaster recovery for households and communities

However, even with robust social protection, accelerating post-disaster recovery remains a critical challenge. While social protection programs alleviate poverty, they may not fully address the immediate needs for communities to bounce back quickly after a disaster. Therefore, governments must complement social protection with targeted socioeconomic interventions that reduce wellbeing losses and accelerate recovery. These efforts include:

- Boosting post-disaster support: According to World Bank research, increasing emergency cash payments from 40% to 60% of losses for poor households can significantly lessen suffering and shorten recovery times, especially in low-income countries.[73] Expanding these support mechanisms and ensuring they reach the most vulnerable quickly can improve economic stability after disasters.
- Reducing economic vulnerability: Helping people move from informal to formal employment spreads financial risk. With formal employment, employers bear the cost of replacing damaged assets (rather than individuals), easing financial strain on households. Self-employment rates are higher in low-income countries, so these reforms could bring substantial benefits in terms of financial resilience and faster recovery.
- Promoting income diversification: Households with multiple income sources, such as social support payments alongside labour wages, are less financially vulnerable to disasters. Providing access to diverse income through financial inclusion initiatives, such as government-backed transfer programs, helps households maintain stability even when local assets are damaged. This is particularly crucial for lower-income households, which otherwise experience the most severe wellbeing losses.

Beyond these, countries can use a disaster risk reduction finance approach to identify other suitable socio-economic actions. This approach considers cost, impact and community needs to ensure targeted and effective actions.

Pre-arranged funding and anticipatory action

These socioeconomic interventions are vital to help communities prepare and recover, but they can only work if resources are available before a disaster strikes. This highlights the need for countries to embrace a comprehensive approach based on pre-arranged funding and proactive action. Pre-arranged funding guarantees that financial resources are accessible ahead of time to quickly implement socioeconomic interventions. Moreover, actions such as distributing drought resistant seeds enable communities to prepare and lessen the impact of disasters. When these two approaches come together, resources are more effective, which can help break the cycle of repeated disaster response. To maximize the effectiveness of pre-arranged funding at the national level, countries can strategically employ specific types of pre-arranged funding, like contingent financing and fiscal buffers.

This is especially important because traditional funding sources often fall short, particularly when governments have limited budgets or when the scale of a disaster is too large. In such cases, the alternative financing tools discussed earlier, such as disaster risk insurance policies, catastrophe bonds and market-based financial instruments, become essential. These tools provide quick access to contingency funds, loans and grants that can supplement public financing when they are most needed.[74] An example of this is the Start Network's Drought Financing Mechanism in East Africa. By providing rapid funding in response to drought forecasts, it aims to ensure that proactive interventions (for instance, distributing drought-resistant seeds and providing veterinary care for livestock) are implemented before the full onset of the crisis to reduce humanitarian costs.[75]

Box 40. The cost-benefits of anticipatory action against drought in Mozambique

If designed well, proactive funding at the national level has proven cost-benefits compared to delayed humanitarian responses. In Mozambique, the Food and Agriculture Organization (FAO) and other United Nations agencies implemented projects under the national drought framework, demonstrating the high cost-effectiveness of anticipatory action. The interventions achieved a strong benefit-cost ratio of 2:25, a total monetized benefit per household of $99 against a cost of $44.19. It significantly improved livestock mortality rates, livestock body condition scores, crop yields and household food security, showcasing the economic value of proactive disaster risk management.[76]

Farmer working on the Baixo Limpopo Irrigation and Climate Resilience Project (BLICRP) in Mozambique

Credit: Jeffrey Barbee/Thomson Reuters Foundation

At the global level

International organizations can strengthen national efforts by providing pre-arranged funding tied to early warning systems, ensuring resources reach high-risk communities before a disaster strikes. This addresses the limitation of national governments that may lack sufficient resources or capacity for proactive measures, and is more cost-effective than traditional humanitarian relief. Additionally, the international system can help free up fiscal space for anticipatory action by promoting debt-for-resilience swaps, as described earlier. The international community can contribute to countries shifting to proactive disaster management by working collaboratively. The example of the donor-funded Pacific Catastrophe Risk Insurance Company and its parametric drought insurance model showcases the role that international development assistance can play in reducing risk to manageable levels 41).

In conclusion, breaking the response-repeat cycle requires integrated forward-looking policies and financial mechanisms to shift from costly emergency relief to proactive risk reduction. While social protection programs can stabilize household incomes, reducing long-term vulnerability, anticipatory finance ensures rapid funding for early action, helping prevent disasters from escalating. Finally, contingent financing and fiscal buffers secure pre-arranged funds, enabling an immediate response. Together, these approaches can ensure timely action before disasters strike and financial stability after they occur, helping countries protect livelihoods, reduce recovery costs and strengthen long-term economic resilience against future shocks.

Box 41. Strengthening disaster preparedness and response to drought in the Pacific through parametric insurance

The Pacific region experiences variable rainfall, leading to both droughts and flooding. The vulnerability of islands varies considerably due to differing water storage: in the context of drought, the higher islands typically have natural water storage systems such as rivers, streams and aquifers, while the lower-lying islands depend solely on rainfall and shallow aquifers for their supply. This variation in hydrology makes the region's vulnerability to drought highly dependent on geographic location and island type.

In this context, the Pacific Catastrophe Risk Insurance Company launched a parametric drought insurance in 2022 with a dual-trigger design, enabling quick payouts for drought preparedness and response. This innovative mechanism addresses financing gaps and aligns with the Pacific Island Countries' specific drought circumstances. This demonstrates the effectiveness of contingent financing, combined with insurance, to enable anticipatory action and rapid response to reduce drought impacts.[77]

Ways forward

Investing in DRR is no longer optional — it is essential for protecting financial stability and enabling long-term development. Sound disaster risk reduction financing strategies can break the spirals of disaster-driven economic distress, protect household income, and reduce national debt, enabling more affordable and accessible insurance and a shift towards proactive risk reduction.

Green energy investments have already created jobs and boosted productivity in many countries. Moving forward, investments in resilient infrastructure can be similarly primed to generate economic growth.

For the private sector, there is significant potential to unlock significant revenue-generating opportunities by leveraging innovative finance instruments and risk-sharing mechanisms and promoting new resilience technologies. This in turn will help scale and accelerate resilience efforts.

This chapter has underscored four key action areas for investing in a safer future:

1. **Understand current and future risk:** By basing national investment on robust risk data, the public sector can more effectively target where resilient infrastructure is best placed and ensure coverage of early warning systems to protect communities

and assets. Similarly, the private sector can use risk analytics to identify vulnerabilities across supply chains and investment portfolios and integrate assessments and climate scenarios into their financial projections and investment planning.

2. **Reduce exposure by sharing or transferring risk:** Resilience requires spreading the costs and benefits of reducing disaster risks across sectors and stakeholders and accelerating recovery after shocks. Expanding the range of risk transfer products and options available and developing multi-year coverage options can help expand coverage and reduce the burden on governments when disasters strike. Tools like sovereign resilience bonds and regional risk pools can help accelerate the speed of recovery. This can be complemented by social protection systems. Insurance policies that are paired with preventive risk reduction can help keep products affordable, while strengthening resilience.

3. **Anticipate disasters and protect against them:** Investing in multi-hazard early warning systems to enhance preparedness can reduce reliance on costly post-event recovery measures. Anticipatory finance, well-tailored to the local environment, saves lives and public sector money. Similarly, private sector investment to prepare for disasters and enhance multi-hazard early warning systems and business continuity plans can mitigate against costly disruptions. Anticipatory actions, such as stockpiling critical materials or diversifying suppliers, can help companies recover faster and be more resilient to disasters.

4. **Track, innovate and learn:** A rapidly evolving disaster risk world means governments and businesses should continuously learn, evaluate and innovate to improve their resilience practices. They must leverage lessons from past disasters to constantly refine and better target resilient investments. Embedding disaster resilience into budget planning and public infrastructure by assigning, tagging and tracking a minimum share of national budgetary resources for resilience can help make this possible. Standardized resilience metrics and taxonomies, can help reporting and tracking of disaster risk exposure, as well as help identify effective resilience action.

Layered financing strategies can combine these efforts into a coherent approach to strengthening financial resilience. For example, low-cost, high-frequency events might be covered through national reserves or contingent credit lines, while rarer, more severe disasters require insurance or other risk-transfer solutions. Enhancing the disclosure of climate risks and embedding resilience measures into investments can help stabilize returns by reducing repayment risks and protecting assets. Securing access to financing ahead of disasters enables countries to quickly respond to the urgent needs of their population, rebuild their economies efficiently, and avoid defaults or debt crises.

The current spirals of unsustainable disaster risk management are not inevitable. Financial institutions and the private sector can shift course, moving from a future defined by escalating costs and instability to one anchored in stability, resilience and opportunity. However, achieving this transformation at scale will require deliberate and coordinated action. The concluding section of this report sets out the key messages for building a more resilient financial future, highlighting the essential steps needed to hardwire risk reduction into investment decisions, strengthen disaster risk financing strategies, and unlock the resilience dividends critical to sustainable development.

[1]European Insurance and Occupational Pensions Authority (EIOPA) and European Central Bank (ECB), 2023.

[2]Bangalore et al., 2017.

[3]Kotz, Levermann and Wenz, 2024. p 555.

[4]Bernhofen et al, 2024. p7.

[5]Agarwala et al., 2024.

[6]Klusak et al., 2023.

[7]Bernhofen et al., 2024.

[8]European Insurance and Occupational Pensions Authority (EIOPA) and European Central Bank (ECB), 2023.

[9]Lloyd's, 2018.

[10]Actuaries Institute, 2024.

[11]Keys and Mulder, 2024. p 1.

[12]European Insurance and Occupational Pensions Authority (EIOPA) and European Central Bank (ECB), 2023.

[13]Idem.

[14]Actuaries Institute 2024, Home Insurance Affordability and Home Loans at Risk, Actuaries Institute, Sydney, viewed 27 April 2025, https://actuaries.asn.au/public-policy-and-media/our-thought-leadership/reports/home-insurance-affordability-and-home-loans-at-risk.

[15]The New York Times, 2025.

[16]UNDRR, 2023.

[17]Hallegatte, Rentschler and Rozenberg, 2019.

[18]Case study for GAR 2025: Ghana – Roadmap for resilient infrastructure in a changing climate. UNOPS, 2024.

[19]Shahab et al., 2024.

[20]https://www.nema.gov.au/our-work/key-programs/disaster-ready-fund

[21]https://ndmindia.mha.gov.in/ndmi/responsefund

[22]UNDRR, 2024.

[23]Sommer et al., 2015.

[24]Green Climate Fund, 2023; Furness, 2024.

[25]Ritu Bharadwaj, 2024.

[26]UNEP et al., 2024.

[27]Bernhofen et al., 2024. p 7.

[28]The Climate Bonds Initiative, 2019; EBRD, 2019.

[29]Choi et al., 2023.

[30]Henry and North, 2024.

[31]IRENA, 2020.

[32]Earth Security, 2022.

[33]Global Center on Adaptation, 2021.

[34]Newlands, 2024.

[35]Climate Bonds Initiative, 2024.

[36]OECD, 2018.

[37]Green Climate Fund, 2022.

[38]Chau et al., 2023.

[39]C40 Cities Climate Leadership Group and C40 Knowledge Hub, 2022.

[40]Jones Day, 2022.

[41]Project Gaia was co-founded by by FinDev Canada, the Green Climate Fund and MUFG bank. https://www.bk.mufg.jp/global/productsandservices/corpandinvest/gcf/pg/index.html

[42]Green Climate Fund, 2023.

[43]Bennett, 2024.

[44]Porsborg-Smith et al., 2022.

[45]Under Article 6.4 of the Paris Agreement.

[46]Bennett, 2023.

[47]Earthshot Prize, 2023.

[48]Although CSRD and CSDDD focus on the EU, their impact extends globally as companies must report on their value chains, which includes suppliers in developing countries, thereby driving resilience investments across borders.

[49]At the time of drafting this section, the European Commission was holding consultations on potential simplifications of the CSRD and CSDDD, with proposals expected by March 2025.

[50]Li et al., 2024.

[51]Chau et al., 2023.

[52]Agarwala et al., 2024.

[53]Seychelles Conservation and Climate Adaptation Trust (SeyCCAT), 2025.

[54]Radhakrishnan et al., 2025.

[55]UNISDR, 2009; UNDRR, 2017.

[56]UN Capital Development Fund, 2021.

[57]European Insurance and Occupational Pensions Authority (EIOPA) and European Central Bank (ECB), 2023.

[58]Idem.

[59]Idem.

[60]World Bank, 2019.

[61]World Bank, 2024.

[62]European Insurance and Occupational Pensions Authority (EIOPA) and European Central Bank (ECB), 2023.

[63]Jamaica Observer, 2024.

[64]World Bank, 2019.

[65]Bouyé Eric, Bourre and Lee, 2019; TIME, 2024.

[66]ICMIF, 2024.

[67]Government of United Arab Emirates and The National Emergency Crisis and Disaster Management Authority, 2025.

[68]Compendium of Good Practices on Community Based Disaster Risk Management – CADRI, 2020.

[69]Ministry of Corporate Affairs - Government of India, 2013.

[70]Tata Sustainability Group, 2023.

[71]Case study developed for GAR 2025: Kanji et al. 2024, Building disaster resilience through corporate social responsibility (CSR): The Indian experience of an alternate financing system.

[72]CADRI Partnership, 2020.

[73]Middelanis, R et Al., 2025.

[74]Case Study for GAR 2025: Building Resilience Through Innovation: Integrating Disaster Risk Finance for Adaptive Social Protection.

[75]Start Network, 2017.

[76]The results showed a 11.1% decrease in pig mortality rate, a 8.47 point improvement in the body condition score of cows, a substantial yield increase in millet and maize crops, and a 15.9% point increase in households with an acceptable Food Consumption Score. Case study developed for AGR 2025: Merzouk et al, 2024. Government-led anticipatory action: lessons learned on interagency coordination and implementation of anticipatory actions in Mozambique.

Case study: Successful investment in anticipatory action and preparedness that created resilience

[77]Anticipation Hub, 2022; PCRIC, 2022a; 2022b.

CHAPTER 7

Conclusion: Resilience Pays

Disaster risk is increasing as more frequent and intense hazard events, unsafe urbanization and ineffective development put more people and assets in harm's way. Disasters have profound macroeconomic impacts, with direct losses estimated at $202 billion and indirect losses nearing $2.3 trillion annually. Current investment patterns fuel spirals that increase debt and decrease income, foster uninsurability and perpetuate an expensive dependence on humanitarian assistance. Disasters are also increasingly associated with credit rating downgrades. Action is essential to protect societies, property values and wider financial and insurance systems.

All countries suffer. Human impacts are more acute in the global south, but economic losses and uninsurability are growing fastest in more developed countries. The world cannot afford this waste when so many of these losses are preventable. Just as total disaster costs have been underestimated, so have the benefits of disaster risk reduction in both developed and developing countries. GAR 2025 highlights dozens of examples where smarter, more risk-informed investments reduce or even prevent disaster losses despite the stark realities of a volatile climate future. It clarifies that managing risk for the 21st century requires action in six key areas as outlined below.

1. Democratize risk understanding

Quality risk information aligned to local realities is fundamental to directing investment effectively to prevent, reduce and manage risk. Risk information must be standardized, accessible, comparable, and, as much as possible, open source. Most of all, it must be global. All countries and markets suffer when risk knowledge is sold only to the highest bidder.

While hazard information is improving globally, governments must do a better job of connecting this to exposure and vulnerability data to better pinpoint risk. As outlined in Chapter 4, doing so can make pro-poor investments more effective, accelerate disaster recovery and protect infrastructure.

Equally important, both the public and private sectors need access to robust risk information and accurate analysis of their likely average annual losses, and, in larger events, their probable maximum losses. This data must be usable by governments, financial markets, central banks and disaster managers. Metrics must be tailored to local realities and meet the needs of a wide range of stakeholders, such as central and local governments and project planners. Tailored metrics can enable financial decision makers to begin prioritizing risk reduction actions by geographic area and by key hazards over the medium to long term. Risk metrics should be complemented by resilience indicators, making the benefits of investing in resilience clearer and easier to integrate into decisions. Harnessing local knowledge and technological advances in machine learning and the appropriate use of artificial intelligence can accelerate trend analysis and the application of new insights into risk.

2. Use public financing and regulation to break the risk-creation addiction

Physical disaster risks must be monitored and managed like any other potential risk to the financial system. What is often seen as unpredictable volatility, or even uncertainty, can be distilled into probabilities and expected losses to be managed and budgeted. Governments have a role in setting guardrails, spreading learning, and improving access to quality risk data. Metrics and taxonomies exist that can be enhanced to increase their coverage and quality through public-private collaborations and standard setting, as UNDRR has already been doing with key partners.

Governments can lead by making disaster risk financing strategies fit for the future core to their operations. These strategies must interlock three elements: risk reduction, risk transfer and improved risk management. These strategies must be based on quality risk information tailored to a country's specific exposure, vulnerability and hazard profile.

When that is done, the evidence clearly shows that resilience pays. It saves lives and reduces the scale of humanitarian catastrophes. Even small, relatively low-cost actions, such as accelerating post-disaster recovery support to households, can yield lasting benefits by stabilizing domestic incomes and helping small businesses stay afloat. These actions also buffer against GDP losses from disasters that can balloon debt levels, decrease credit ratings and derail development. When disaster risk reduction works, emergencies are prevented, and development investment goes further.

Reaping the rewards of resilience also requires ring-fencing disaster risk reduction budgets to empower responsible agencies and mainstreaming disaster risk reduction across sectors and plans. It means implementing appropriate accountability mechanisms, including budget tagging and tracking systems for DRR-related losses and expenditures. It also means keeping track of how ministries have articulated and allocated funds across the layers of risk management and systematically capturing lessons on what worked and what needs improvement after disasters.

Measuring disaster resilience across sectors is essential to ensure that standards are applied consistently to public investments, now and in the future. This, in turn, is important for entities such as public pension funds so that younger generations remain confident that the contributions they make today will retain their future value.

3. Innovate to keep risk transfer and insurance sustainable

Risk transfer mechanisms, such as insurance, can no longer thrive unless governments and companies ensure their actions are more resilient to disaster shocks. To quote Prime Minister Mia Mottley of Barbados, "When a sector or a country or a region becomes uninsurable, they effectively become uninvestable."[1] Risk transfer has great potential to incentivize risk reduction. If a country invests in risk reduction, insurance premiums should come down. When insurance companies are required to publish coverage and non-renewal data annually, it sends a powerful signal to markets about the price of unsafe infrastructure, supply chains and areas where risk is increasing. As volatility in hazard patterns increases, scaling up the pool of people and assets protected by public and/or private sector-backed risk transfer mechanisms is essential to take resilience-building to scale.

Making this work will require insurers to evolve: rather than pricing premiums solely around replacement costs, they must enable rebuilding to a standard fit for the future, and design products that are better adapted to their specific contexts. Insurance products have often struggled when transplanted wholesale from developed to developing countries without adaptation. This has frequently created affordability challenges or eroded trust between policyholders and insurers. A more tailored approach that supports insurance in easing the relief burden on governments while protecting consumers is essential if risk transfer tools are to succeed across developed and developing contexts, as illustrated by the case studies presented in chapters 4 and 6.

Beyond domestic and commercial insurance, finance for adaptation and loss and damage are among the risk-sharing instruments that offer considerable potential for expansion. Needs-based social safety nets have long functioned in areas such as public health to cover individuals against rare but predictable diseases. The same kind of social safety nets must now emerge at scale to protect low-income workers from infrequent but high-impact disasters (such as periods of extreme heat, when outdoor work is impossible) and to ensure that recovery assistance reaches poor households quickly.

4. Make the business case

The private sector accounts for about 75% of capital investment in most economies, but if these investments are not risk-informed, societal resilience will remain out of reach. There is significant scope for innovation and co-financing partnerships to incentivize private sector modernization and investment in disaster risk reduction. Much of the world's hidden disaster risk is concentrated in underinsured companies and is increasingly exposed to direct damage, supply chain disruption, and broader financial volatility.

Increasingly investments underpinned by sound plans to manage risk and future volatility will continue to attract financing to meet sustainable development targets. Others may struggle. A lack of risk understanding cannot be allowed to hamper investment and development, particularly in countries that need it most.

Communities and companies have centuries of experience in coping with disasters and taking action to reduce risk. Today, at the dawn of a new information age, their capacities can be vastly strengthened by applying artificial intelligence to accelerate learning and analyse trends across many areas of disaster management. At the same time, advances in engineering and emerging resilient technologies offer new opportunities to build more safely and affordably. Industries, such as insurance, recognize that their expertise in risk analytics has value beyond underwriting. It helps to identify and scale up safer, and, therefore, more investable, infrastructure. These efforts deserve recognition, incentives, and other strategic tools to ensure a just green transition and sustainable future.

5. Anticipate shocks to reduce humanitarian need

Because resilience-building to date has been insufficient, many vulnerable countries remain trapped in a vicious cycle of disaster, response and recovery, only to repeat the pattern again and again. The international community has a shared responsibility and interest in breaking the cycle. This requires scaling up anticipatory action and finance, while also increasing the percentage of aid activities targeting disaster risk reduction beyond the current global level of 2%.

It also requires a shift in mindset, recognizing that disasters arise not just from hazards, but from underlying vulnerabilities or heightened exposure that enable hazards to escalate into a humanitarian crisis. Employing low-cost tools, such as disaster forensic analysis, to pinpoint these factors is essential because recovery efforts to reduce core vulnerabilities or the most damaging exposures are more cost-effective and have the greatest potential to prevent future crises.

Reducing humanitarian needs saves lives and decreases suffering. It is also cost-effective and benefits individuals, societies, economies and the environment, even decades after a shock. Reducing needs during a disaster is impossible. It requires careful, proactive risk reduction to prevent hazards from escalating into disasters.

6. Leverage the multiplier effect of international financial mechanisms

International finance institutions and public planners must harness the power of increasingly globalized financial markets to share risk more broadly, find better ways to prevent fiscal gaps and support faster, better-targeted recovery, ensuring that disasters do not create humanitarian needs and long-term suffering.

Increasing resilience can deliver significant efficiency gains. These must be central to how multilateral donors and development banks protect their portfolios from the cascading impacts of disaster volatility. Even relatively modest interventions, such as extending reinsurance-style coverage to absorb a share of GDP losses when LDCs and SIDS are impacted by a major disaster, can prevent debt defaults and avert decades of stalled development. Resilience pays, and concrete measures to buffer against disaster shocks should become standard in designing sovereign loan programs and prioritizing official development assistance (ODA).

As multilateral systems evolve to address complex challenges such as adaptation and loss-and-damage finance, it will be essential to draw lessons from risk pooling and reinsurance. This requires innovation and sustained learning, but the potential benefits are substantial. There are mechanisms in place that can be strengthened to facilitate this, such as the Santiago Network, which aims to provide much-needed technical assistance to developing countries for building resilience to loss and damage.

In many contexts, tools like ODA and, increasingly, climate adaptation finance should be used to help fiscally constrained countries enhance their resilience. This supports long-term stability and increases aid effectiveness, given that disaster risk reduction measures often deliver some of the highest benefit-cost ratios, ranging from 2:1 to 10:1 or more.

Act now: break the cycle and build resilience

Breaking the current destructive cycle of disaster, recovery, and debt is urgent and essential for continued prosperity in a climate-changed world. The rising costs and intensifying frequency of disasters can no longer be treated as isolated events. They are systemic threats that demand a fundamental shift in how risk is understood, financed and managed globally. By embedding disaster risk reduction at the heart of financial decisions and policy frameworks, governments, businesses and communities can interrupt harmful cycles of vulnerability, loss and debt while accelerating sustainable, equitable development.

The pathway beyond 2030 need not be defined by shocks and piecemeal, unplanned recovery; instead, proactive investment in resilience can pave the way to a future defined by stability, prosperity and sustainable progress. The opportunities for transformative action are clear. Now it is up to decision-makers across the globe to seize them.

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[1] https://www.foreign.gov.bb/rising-insurance-costs-a-threat-to-barbados-competitiveness/

Abbreviations and acronyms

AA	Anticipatory Action
AAEC	Average Annual Embodied Carbon
AAL	Annual Average Loss
AI	Artificial intelligence
ARC	African Risk Capacity
ASEAN	Association of Southeast Asian Nations
ASIS	Agricultural Stress Index System
AUD	Australian Dollar
BBC	British Broadcasting Corporation
BCCR	Central Bank of Costa Rica
BCR	Benefit-Cost Ratio
BdF	Banque de France
BERLAC	Capacity Building for Disaster Risk Reduction in the Built Environment in Latin America and the Caribbean project
BN	Billion (109)
BSC	Balanced Scorecard
°C	Degrees Celsius
CAD	Canadian Dollar
CAR	Capital Adequacy Ratio
CBI	Climate Bonds Initiative
CCA	Climate Change Adaptation
CCH	WHO Team Climate Change and Health
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CDR	Carbon Dioxide Removal
CDRI	Coalition for Disaster Resilient Infrastructure
COP	Conference of the Parties
COVID-19	Coronavirus Disease 2019

CO2e	Carbon Dioxide equivalent
CRED	Centre for Research on the Epidemiology of Disasters
CRT	Catastrophe Risk Transfer
CSOs	Civil Society Organizations
CSR	Corporate Social Responsibility
DALY	Disability-Adjusted Life Year
DDLD	Desertification, Land degradation and Droughts
DDRM	Dynamic Disaster Risk Model
DFIs	Development Finance Institutions
DFID	Department for International Development of the United Kingdom
DRF	Disaster Ready Fund
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DTM	Displacement Tracking Matrix
DTS	Disaster Tracking System for hazardous events and losses and damages
EAP	East Asia and Pacific
EBRD	European Bank for Reconstruction and Development
ECLAC	Economic Commission for Latin America and the Caribbean
ECV	Essential Climate Variable
EDC	Economic Development Corporation
EHC	WHO Team Environment, Climate Change and Health
EM-DAT	Emergency Events Database
EOSDIS	Earth Observing System Data and Information System
EQ	Earthquake
EW4ALL	Early Warnings for All initiative
FAO	Food and Agriculture Organization of the United Nations
FM	Financial Management
GAR	Global Assessment Report
GB	Great Britain
GDP	Gross Domestic Product
GEM	Global Earthquake Model

GEO	Group on Earth Observations
GIRI	Global Resilience Risk Model and Resilience Index or Global Infrastructure Risk Index
GRID	Global Resource Information Database
GRM	Global Risk Model
GSDR	Global Sustainable Development Report
GT	Gigatonne (10^9 t)
HFA	Hyogo Framework for Action 2005-2015
HFH	Habitat for Humanity
HICs	High Income Countries
HLPF	High-Level Political Forum on Sustainable Development
IADB	Inter-American Development Bank
IBFI	Index-Based Flood Insurance
IDB	Inter-American Development Bank
IDF	aa
IDMC	Internal Displacement Monitoring Centre
IDPs	Internally Displaced Persons
IEA	International Energy Agency
IFRC	International Federation of Red Cross and Red Crescent Societies
IIASA	International Institute for Applied Systems Analysis
IIED	International Institute for Environment and Development
ILO	International Labour Organization
ILS	Insurance-Linked Securities
IMF	International Monetary Fund
INGO	International Non-Governmental Organization
INR	Indian Rupee
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
ISC	International Science Council
ISDR	International Strategy for Disaster Reduction
ISF	Integrated Strategic Framework
ITF	International Transport Forum

IVR	Impacts, Vulnerability and Risks
JICA	Japan International Cooperation Agency
Kg/m2	Kilograms per square meter
LDCs	Least Developed Countries
LIDAR	Light Detection and Ranging
LIC	Low-Income Country
LL	Lessons Learned
LLDCs	Landlocked Developing Countries
LLP	Limited Liability Partnership
LMICs	Low- and Middle-Income Countries
LRAs	Local Resilience Agents
M&E	Monitoring and Evaluation
MDR	Mortality Disaster Risk
MHEWS	Multi-Hazard Early Warning System
MMI	Max intensity
Mw	Moment magnitude of earthquakes size
MODIS	Moderate Resolution Imaging Spectroradiometer
NAP	National Adaptation Plan
NASA	National Aeronautics and Space Administration
NDCs	Nationally Determined Contributions
NDRRMC	National Disaster Risk Reduction Management Council of the Philippines
NGFS	Network of Central Banks and Supervisors for Greening the Financial System
NTL	Night-Time Lights
nVAR	Nature Value at Risk
NW	Net Worth
OCHA	UN Office for the Coordination of Humanitarian Affairs
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
PAF	Pre-Arranged Financing
PCRIC	Pacific Catastrophe Risk Insurance Company
PDC	Pyroclastic Density Current

PM2 Fine particulate matter < 2 µm

PM2.5 Fine particulate matter < 2.5 µm

PML Probable Maximal Loss

PPP Purchasing Power Parity or Public–Private Partnership

PV Photovoltaic

RCP Representative Concentration Pathway

SDG Sustainable Development Goals

SDR Special Drawing Rights

SEADRIF Southeast Asia Disaster Risk Insurance Facility

SEI Stockholm Environment Institute

SFM Sendai Framework Monitor

SIDS Small Island Developing States

SLR Sea-Level Rise

SNA System of National Accounts

Sq Km Square kilometers

SRES Special Report on Emissions Scenarios

SSP Shared Socio-economic Pathways or Surface Seismic Profile

STEPS Stated Policies Scenario

TW Terawatt (10^{12} W)

U-M University of Michigan

UCLouvain Université Catholique de Louvain

UDMCs Union Disaster Management Committees

UHI Urban Heat Island effect

UMICs Upper middle-income countries

UN United Nations

UNCCD United Nations Convention to Combat Desertification

UNDP United Nations Development Programme

UNDRR United Nations Office for Disaster Risk Reduction

UNEP United Nations Environment Programme

UNESCO United Nations Educational, Scientific and Cultural Organization

UNFCCC United Nations Framework Convention on Climate Change

UNHCR	UN High Commissioner for Refugees
UNICEF	UN Children's Fund
UNSCDF	UN Sustainable Development Cooperation Framework
US	United States of America
USD	United States Dollar
USGS	United States Geological Survey
VAT	Value-Added Tax
WASH	Water, Sanitation and Hygiene
WFP	World Food Programme
WHO	World Health Organization
WMO	World Meteorological Organization
YLD	Years Lived with Disability
YLL	Years of Life Lost

Glossary

Anticipatory action fund: pre-agreed public reserve that releases cash before a forecast event to blunt losses.[1]

Average Annual Embodied Carbon (AAEC): yearly expected CO_2 locked into reconstruction when buildings fail.[2]

Average Annual Loss (AAL): Expected monetary loss per year due to disaster events. It is calculated by averaging potential losses over a long period, considering both frequent small-scale events and rare high-impact disasters. Typically derived from probabilistic risk models that analyze historical disaster data (often spanning 50 to 100 years) and future projections. The calculation aggregates losses across different hazard intensities and likelihoods over time, ensuring a comprehensive risk assessment.[3]

Blended finance: Strategic use of development finance for the mobilization of additional finance towards sustainable development in developing countries.[4]

Blue bond: Debt instrument issued by governments, development banks or others to raise capital from impact investors to finance marine and ocean-based projects that have positive environmental, economic and climate benefits. The blue bond is inspired by the green bond concept, which people are more familiar with.[5]

Budget tagging: Labeling, quantifying and tracking public resilience investments in an integrated fashion, governments can enhance resource allocation and efficiency in public expenditure. Marking and tracking disaster-risk-reduction and climate-adaptation spending lines throughout a government's budget cycle to spot gaps and overlaps.[6]

Capacity: The strengths, resources and skills available to anticipate, cope with and recover from disasters.[7]

Carbon finance / carbon credits: monetizing greenhouse-gas reductions while delivering local risk-reduction co-benefits.[8]

Cascading costs or Indirect economic loss: a decline in economic value added as a consequence of direct economic loss and/or human and environmental impacts.[9]

Catastrophe bond: debt instrument that allows the issuer to get funding from the capital market, if and only if catastrophic conditions, such as a hurricane, occur.[10]

Catastrophic risk: Events are defined as those that result in over 10 million fatalities, or greater than $10 trillion in damages, essentially the damage must be extensive and on a global scale.[11]

Climate-induced credit downgrade: sovereign rating cut driven by mounting, unmanaged hazard risk.[12]

Climate-resilience (or "resilience") bond: a labelled bond whose proceeds fund adaptation/DRR; may embed features like interest deferral after a disaster.[13]

Compound hazard: two or more hazards interacting or occurring close together to amplify damage15.

Cost-benefit analysis (CBA): valuation method comparing the discounted benefits of DRR to its up-front cost.[14]

Critical infrastructure: The physical structures, facilities, networks and other assets which provide services that are essential to the social and economic functioning of a community or society.[16]

Debt-for-resilience / debt-for-nature swap: restructuring sovereign debt in return for DRR or ecological spending.[17]

Development Finance Institution (DFI): publicly backed lender or sponsor that de-risks or co-finances resilience investments in high-risk markets.[18]

Direct economic loss: The monetary value of total or partial destruction of physical assets existing in the affected area. Direct economic loss is nearly equivalent to physical damage.[19]

Disability-Adjusted Life Year (DALY): represents the loss of the equivalent of one year of full health. DALYs for a disease or health condition are the sum of the years of life lost to due to premature mortality and the years lived with a disability due to prevalent cases of the disease or health condition in a population.[20]

Disaster Tracking System (DTS): next-generation toolkit linking hazard parameters with fully disaggregated loss data.[21]

Early-warning Systems / MHEWS: An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events.[22]

Ecosystem services: flows of benefits that people, firms and public authorities obtain from functioning ecosystems.[23]

Embodied carbon: greenhouse-gas emissions embedded in construction materials that are wasted when assets fail.[24]

Exposure: The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas.[25]

Extensive Disaster Risk: The risk of low-severity, high-frequency hazardous events and disasters, mainly but not exclusively associated with highly localized hazards.[26]

Financing gap / Fiscal gap: the shortfall between expected disaster costs and the funds a government has available, which can trigger a fiscal crisis.[27]

Fiscal crisis: episode in which a government's public-finance position becomes acutely unsustainable, forcing default, a restructuring of obligations, recourse to exceptional official or International Monetary Fund financing, or other emergency measures to restore solvency.[28]

Fiscal gap: probability that losses exceed budget, forcing expensive borrowing.[29]

Green bond: a labelled bond that channels part of its proceeds to DRR/adaptation measures alongside low-carbon activities.[30]

Gross Domestic Product (GDP): the total monetary value of all final goods and services produced within a country.[31]

Hazard: A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.[32]

Index-Based Flood Insurance (IBFI): community parametric cover that pays when river heights cross set thresholds.[33]

Intensive Disaster Risk: The risk of high-severity, mid- to low-frequency disasters, mainly associated with major hazards.[34]

Layered risk management: combining risk reduction, retention and transfer in complementary layers of protection.[35]

Natural capital: stocks of biodiversity, soil, water and other ecosystems.[36]

Nature Value at Risk (nVaR): share of GDP at risk from ecosystem degradation and nature-related shocks.[37]

Parametric insurance: policy triggered by a measurable hazard parameter rather than post-loss assessment.[38]

Probabilistic risk model: simulation that generates distributions of AAL, PML and other metrics for planning.[39]

Probable Maximum Loss (PML): single-event loss that can be expected at or beyond a chosen return period.[40]

Public debt / Sovereign debt: the stock of outstanding government liabilities.[41]

Residual risk / Risk retention: The disaster risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained.[42]

Resilience dividend: net benefit (or cost) that accrues, from investments aimed at increasing resilience, in the absence of a disruptive incident over the planning horizon.[43]

Resilience pool: multinational parametric facility that spreads disaster risk and delivers rapid payouts.[44]

Risk reduction: preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development.[45]

Risk transfer: The process of formally or informally shifting the financial consequences of specific risks from one party to another, whereby a household, community, enterprise or State authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party.[46]

Sovereign credit rating: assessment of a state's repayment capacity.[47]

Special Drawing Rights (SDR): International Monetary Fund reserve asset that can be tapped or re-channeled to soften post-disaster fiscal shocks.[48]

Systemic risk: risk that is endogenous to, or embedded in, a system that is not itself considered to be a risk and is therefore not generally tracked or managed, but which is understood through systems analysis to have a latent or cumulative risk potential to negatively impact overall system performance when some characteristics of the system change.[49]

Vulnerability: The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.[50]

Well-being loss: The utility of foregone consumption during the recovery from a disaster. The utility of $1 of consumption thereby depends on a person's wealth and reflects that the impact on wellbeing of $1 of consumption losses is bigger for a poor person than for a wealthier person.[51] At the country level depends on the distribution of impacts within the population, but it is expressed as the equivalent loss in national consumption.[52]

Risk to assets: Average monetary value of the damages that disasters inflict on assets, often measured as replacement or repair value.[53]

Socioeconomic resilience: An economy's ability to minimize the impact of asset losses on well-being.[54]

[1]World Bank, 2024c.

[2]United Nations Environment Programme, 2023.

[3]UNDRR, 2015; CDRI, 2023; Federal Emergency Management Agency, 2020.

[4]OECD, 2018.

[5]World Bank, 2018.

[6]Intergovernmental Panel On Climate Change (Ipcc), 2023b.

[7]UNDRR, 2017a.

[8]World Bank, 2024d

[9]UNDRR, 2017e

[10]Ando et al., 2022

[11]UNDRR (United Nations Office for Disaster Risk Reduction), 2022

[12]Idem

[13]World Bank, 2024a

[14]Intergovernmental Panel On Climate Change (Ipcc), 2023b; Nature, 2022

[15]World Bank, 2010

[16]UNDRR, 2017b

[17]IMF - Chamon et al., 2022

[18]Overseas Development Institute (ODI), 2010

[19]UNDRR, 2017e

[20]WHO, 2024

[21]UNDRR, 2023

[22]UNDRR, 2017d

[23]Intergovernmental Panel On Climate Change (Ipcc), 2023a

[24]United Nations Environment Programme, 2025

[25]UNDRR, 2017f

[26]UNDRR, 2017g

[27]Dijkman, 2010

[28]Cerovic et al., 2018; Medas et al., 2018

[29]Cattelan, 2024

[30]World Bank, 2024b

[31]United Nations Statistical Office, 2025; IMF, 2025a

[32]UNDRR 2017h

[33]World Bank and UNEP 2015

[34]UNDRR 2017i

[35]World Bank 2014

[36]UNEP 2025

[37]Bernhofen et al. 2024

[38]World Bank 2024b

[39]CDRI 2025

[40]CDRI 2025

[41]IMF 2014

[42]UNDRR 2017j

[43]Fung and Helgeson 2017

[44]Martinez-Diaz, Sidner, and McClamrock 2019

[45]UNDRR 2017c

[46]UNDRR 2017k

[47]Bhatia 2002

[48]IMF 2025b

[49]UNDRR 2019

[50]UNDRR 2017l

[51]Middelanis, R et al. 2025

[52]Hallegatte et al. 2017

[53]Hallegatte et al. 2017

[54]Hallegatte et al. 2017

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Summary Methodology – Estimated Annual Cost of Disasters for GAR 2025

Objective: The goal of this exercise was to establish a historical trend analysis of the rising economic costs of disasters, including environmental hazards such as biodiversity loss and land degradation, as well as cascading impacts on health systems, displacement and human wellbeing, which are all mentioned in the Sendai Framework for Disaster Risk Reduction. This exercise compiled data from various organizations within the United Nations system and other relevant sources. **The aim was to provide a more objective view, recognizing that many publicly discussed economic cost estimates of disaster impacts lack a comprehensive perspective, undervaluing the significance of the cascading cost categories.** By combining this data with recent academic research on future disaster cost projections due to climate change impacts, we aim to gain a clearer understanding of our current situation and the economic trajectory of disasters.

Data used for the analysis: This exercise utilized several datasets from different organizations. For direct economic cost estimates, we primarily used EM-DAT, as it compiles information from diverse sources and is the most widely used global database by public and private organizations, civil society and academics in the fields of risk reduction and disaster management.

For quality reasons, the analysis uses a time series from the year 2000 to 2023, as stated by the Centre for Research on the Epidemiology of Disasters (CRED). EM-DAT collects data on events with at least 10 deaths or 100 people affected. For events below this threshold, we used the UNDRR supported Disaster Loss Event Accounting System (Desinventar) database, which contains information directly from member states and is managed by UNDRR.

To avoid double-counting events between Desinventar and EM-DAT, we conducted a matching exercise based on characteristics such as country, year, event type, and any available identifying information. Where duplicates were detected, we generally retained the more complete dataset, often EM-DAT, due to its standardized coverage and consistent reporting. We also acknowledge that many Desinventar databases have not been updated for up to 15 years, which limits coverage of more recent events. Consequently, only a small subset of records from Desinventar met the criteria for inclusion (219 events representing 2.1% of the total merged dataset with EMDAT), thus minimizing the risk of duplication and reflecting the recognized data gaps in Desinventar.

To capture data on cascading economic losses, we considered the following data sources, as listed below:

Category	Cost	Source
Direct economic losses – excluding droughts	181.6 billion in 2023	EMDAT (2000 to 2023) N=10,256 events
		Desinventar (2000 to 2019 – Median year: 2004) N=219 events
Costs of Deaths - using GDP per capita	61 billion	EMDAT + Desinventar + World Bank data
People (Social)		
Health Costs	$120 billion/year US$ 2–4 billion per year by 2030	WHO
Mental health, air pollution and inadequate access to green space 47 billion per year	47 billion per year	WHO
Displacement (from conflict or disasters)	21 billion in 2021 • Global estimates of displacement impacts are based on the direct costs for IDPs across five dimensions – housing, livelihoods, education, health and security. These costs are derived from HNOs and HRPs in eight countries, primarily covering conflict and violence situations, meaning disaster-related costs are largely excluded. • The total global cost is estimated by multiplying the cost per IDP by the total number of reported IDPs at the end of the year. However, this figure does not account for all displaced individuals throughout the year, particularly those who return home after a disaster within the year, leading to significant underestimation	IDMC
Planet (Environmental)		
Global economic costs due to invasive species	$423 billion in 2019	IPBES
Crop and livestock Losses	123 billion/year	FAO
Pollinator Loss Risks - crops	$160 – $191 billion/year	FAO - IPBES
Pollinator Loss Risks - non crops markets	207 – $497 billion/year	FAO - IPBES
Biodiversity loss overfishing	Overfishing costs more than $83 billion a year in lost revenues- 2012	WB
Desertification, Land degradation and droughts	878 billion per year (Land degradation + droughts)	UNCCD
Sealevel rise	The value of exposed infrastructure amount to more than USD 1800 billion	UNEP - GRID

Key Steps: The exercise was conducted in the following stages:

1. Gathered information from organizations and the UN system regarding studies on the unobserved costs of disasters and their impact on the climate, environment, and social structures.

2. Explored the EMDAT and Desinventar databases to generate data on direct costs. We used EM-DAT data from 2000 to 2023, consistent with the most recent reporting available, using the inflation-adjusted figures. Similarly, data from the Desinventar from 2000 to 2019 were included, though it should be noted that the dataset does not uniformly provide inflation-adjusted values, so additional adjustments were made where feasible to ensure consistency.

3. Integrated World Bank datasets on GDP per capita, GVA, and total population by year and country to generate complementary data and derive other unobserved costs.

4. After consolidating the available data, we generated annual projections for categories lacking historical trends by applying the observed annual growth rates of "people affected" derived from EMDAT (2000–2023). This approach captures temporal dynamics and provides a more robust framework for assessing the cascading economic impacts, recognizing that certain categories do not have sufficient data for a direct historical trend

5. Generated future cost estimates using the damage function developed by Kotz et al. and integrated these into the overall cost record.

Techniques and Tools: The data analysis was performed entirely in R and plot creation in R and excel.

The following table describes the technical process to include the values within the timeline frame.

Category	Inclusion technique
Direct economic loss + Complementary direct economic losses for small events	Adjusted damage costs were summed by year and, for various analyses, also aggregated by country, subregion, and disaster type. We used adjusted damage costs rather than current damage costs because the former accounts for inflation cost[1], a key variable in economic disaster management as widely discussed in the literature. It is important to note that a significant portion of the dataset lacks information on both adjusted and current damage costs (68.5% of missing values). We chose not to impute or estimate these missing values, as the available information across different groupings was insufficient to produce robust estimations. Most of the missing values are on events located in Africa (91.6%), Micronesia (81.9%) and Northern Africa (82.4%).

[1]Cevik, Serhan, and João Tovar Jalles. 2023. "Eye of the Storm: The impact of climate shocks on inflation and growth." IMF eLibrary, April. https://doi.org/10.5089/9798400241307.001.A001.

Costs of Deaths - using GDP per capita	Data from the World Bank, specifically GDP per capita by country and year, were merged into the database. The reported number of deaths, from both EMDAT and SFM, was then multiplied by the corresponding GDP per capita values. These results were computed in the final estimations as we believe after analysis, that GDP per capita is a stronger metric than GVA per capita for measuring the cost of deaths from disasters because it incorporates the comprehensive economic value of consumption (bolstered by taxes and subsidies) that is lost when an individual dies. The methodology in question does not differentiate between ages, based on the rationale that consumption occurs at all stages of life. Regardless of age, each individual contributes to economic consumption, and their death results in a measurable loss of consumption potential. GDP per capita, by encompassing consumption across the entire population, appropriately captures this loss. In contrast, GVA per capita, with its narrow focus on production, does not fully account for the loss in consumption that occurs regardless of age. While this analysis offers valuable insights into the economic impacts of deaths caused by disasters, further research is essential. While the Value of a Statistical Life (VSL), the Human Capital (HC) approach, and Disability-Adjusted Life Years (DALYs) are recognized methods for quantifying mortality costs or health burdens, they are not widely applied in disaster contexts at scale. Presently, no comprehensive, standardized dataset exists that uses these methods for historical, multi-country disaster data. By contrast, GDP per capita is broadly available across countries and years, making it a more practical and consistent proxy for approximating the economic impact of disaster-related deaths. Although this approach is relatively simplistic—focusing on average economic productivity rather than nuanced measures of well-being—it offers a workable baseline for comparative analysis. Moreover, efforts by organizations such as the OECD are underway to develop frameworks that incorporate DALYs for disasters and climate change, but these data remain incomplete, preventing a robust, long-term analysis at this time. Similarly, while VSL and HC methodologies could provide additional insights, they require extensive, context-specific inputs (e.g., local wage rates, detailed demographic data) that are not readily available for historical disaster events across diverse regions. Thus, for the purposes of this study, GDP per capita provides a feasible and uniform metric. Future research may refine these estimates by adopting VSL, HC, or DALY-based calculations as more comprehensive datasets and methodologies become accessible.
Health Costs	The annual values reported by the previously mentioned organizations were collected. These data served as the basis for applying the annual growth rate of affected individuals, which was then used to extrapolate and generate estimates for years lacking direct information. This approach allowed for the calibration of cost estimates according to the unique dimensions of each disaster, ensuring that the projections dynamically reflected changes in both the magnitude and frequency of events. By relying on empirical data and adjusting projections using observed growth rates, the precision and validity of the results are reinforced, thereby providing a solid methodological framework for assessing the cascading economic impact of this event.

Mental health, air pollution and inadequate access to green space	The annual values reported by the previously mentioned organizations were collected. These data served as the basis for applying the annual growth rate of affected individuals, which was then used to extrapolate and generate estimates for years lacking direct information. This approach allowed for the calibration of cost estimates according to the unique dimensions of each disaster, ensuring that the projections dynamically reflected changes in both the magnitude and frequency of events. By relying on empirical data and adjusting projections using observed growth rates, the precision and validity of the results are reinforced, thereby providing a solid methodological framework for assessing the cascading economic impact of this event.
Displacement	Data developed by IDMC and provided to UNDRR
global economic costs due to invasive species	The annual values reported by the previously mentioned organizations were collected. These data served as the basis for applying the annual growth rate of affected individuals, which was then used to extrapolate and generate estimates for years lacking direct information. This approach allowed for the calibration of cost estimates according to the unique dimensions of each disaster, ensuring that the projections dynamically reflected changes in both the magnitude and frequency of events. By relying on empirical data and adjusting projections using observed affected growth rates, the precision and validity of the results are reinforced, thereby providing a solid methodological framework for assessing the cascading economic impact of this event.
Crop Losses	The annual values reported by the previously mentioned organizations were collected. These data served as the basis for applying the annual growth rate of affected individuals, which was then used to extrapolate and generate estimates for years lacking direct information. This approach allowed for the calibration of cost estimates according to the unique dimensions of each disaster, ensuring that the projections dynamically reflected changes in both the magnitude and frequency of events. By relying on empirical data and adjusting projections using observed affected growth rates, the precision and validity of the results are reinforced, thereby providing a solid methodological framework for assessing the cascading economic impact of this event.
Pollinator Loss Risks - crops	The annual values reported by the previously mentioned organizations were collected. These data served as the basis for applying the annual growth rate of affected individuals, which was then used to extrapolate and generate estimates for years lacking direct information. This approach allowed for the calibration of cost estimates according to the unique dimensions of each disaster, ensuring that the projections dynamically reflected changes in both the magnitude and frequency of events. By relying on empirical data and adjusting projections using observed affected growth rates, the precision and validity of the results are reinforced, thereby providing a solid methodological framework for assessing the cascading economic impact of this event.
Pollinator Loss Risks - non crops markets	The annual values reported by the previously mentioned organizations were collected. These data served as the basis for applying the annual growth rate of affected individuals, which was then used to extrapolate and generate estimates for years lacking direct information. This approach allowed for the calibration of cost estimates according to the unique dimensions of each disaster, ensuring that the projections dynamically reflected changes in both the magnitude and frequency of events. By relying on empirical data and adjusting projections using observed affected growth rates, the precision and validity of the results are reinforced, thereby providing a solid methodological framework for assessing the cascading economic impact of this event.

Crop Losses	Each year – from 2000 to 2023 – was reported with 93.66 billion USD of losses as requested by FAO colleagues.
Biodiversity loss overfishing	The annual values reported by the previously mentioned organizations were collected. These data served as the basis for applying the annual growth rate of affected individuals, which was then used to extrapolate and generate estimates for years lacking direct information. This approach allowed for the calibration of cost estimates according to the unique dimensions of each disaster, ensuring that the projections dynamically reflected changes in both the magnitude and frequency of events. By relying on empirical data and adjusting projections using observed affected growth rates, the precision and validity of the results are reinforced, thereby providing a solid methodological framework for assessing the cascading economic impact of this event.
Sealevel rise	The annual values reported by the previously mentioned organizations were collected. These data served as the basis for applying the annual growth rate of affected individuals, which was then used to extrapolate and generate estimates for years lacking direct information. This approach allowed for the calibration of cost estimates according to the unique dimensions of each disaster, ensuring that the projections dynamically reflected changes in both the magnitude and frequency of events. By relying on empirical data and adjusting projections using observed affected growth rates, the precision and validity of the results are reinforced, thereby providing a solid methodological framework for assessing the cascading economic impact of this event.

For future cost projections, using the Kotz et al. damage function, which uses a Fixed-Effects Distributed Lag Model and Monte Carlo Simulations for Uncertainty to simulate future damages and costs. This approach allows for systemic estimations of long-term damages, accounting for feedback loops such as productivity loss, infrastructure disruptions, and supply chain effects.

<table>
<tr><th colspan="2">Kotz et Al 2024. The economic commitment of climate change.</th></tr>
<tr><td colspan="2">Uses aggregate economic indicators (like GDP projections) and climate-economic models to simulate future damages and costs. This allows for systemic estimations of long-term damages, accounting for feedback loops (productivity loss, infrastructure disruptions, and supply chain impacts). It incorporates dynamic interactions between climate, economy, and sectors.</td></tr>
<tr><td>Kotz model incorporates:

• Future climate scenarios: Costs scale up with higher warming pathways due to rising disaster frequencies, intensities, and feedback effects.

• Economic Growth: Future GDP is expected to grow, so damages in absolute terms (billions/ trillions) will also increase.

• Climate Impacts: Includes cascading effects (productivity loss, healthcare burdens, migration), integrating sectoral dependencies and global feedback loops (e.g., energy systems, infrastructure damage, supply disruptions).</td><td>• Climate Data: Historical daily temperature and precipitation data (1979–2019) from the W5E5 database, downscaled to a 0.5° grid. Several components of climate are analyzed annually for each region, including:
» Annual mean temperature
» Daily temperature variability
» Total annual precipitation
» Number of wet days
» Extreme daily rainfall

• Economic Data: Sub-national economic output data (gross regional product per capita, GRPpc) from 1,660 regions across 83 countries.</td></tr>
<tr><td>Empirical Model: Fixed-Effects Distributed Lag Model.

Fixed-effects panel regression model with lagged climate variables to measure how changes in climate affect regional economic growth rates</td><td>Fixed effects control for:

• Regional differences (geography, historical factors).
• Year fixed effects (economic recessions, el Nino).
• Regional time trends to remove spurious correlations.

Lags: The model includes up to 10 years of lagged effects to account for delayed and persistent impacts of climate shocks on economic growth.</td></tr>
<tr><td>Monte Carlo Simulations for Uncertainty: sample across 21 CMIP-6 climate models. Vary lag structures and empirical estimates using 1,000 bootstrap resamples.</td><td></td></tr>
</table>

Reservations and Caveats

As stated from the outset, the objective of this exercise is to foster a discussion regarding the limited visibility of the cascading costs that disasters impose on society and the environment.

The intention here is to illustrate the potential scale and variety of disaster-related costs, rather than to provide a definitive total. **Readers should interpret these figures with caution,** recognizing the differences in measurement units, time horizons, and underlying assumptions. Future efforts to refine the methodology and avoid double counting will help provide a more comprehensive and accurate picture of these impacts.

However, several important caveats must be noted:

1. The EMDAT database was primarily employed because it is currently the most comprehensive historical source of disaster data. Nonetheless, it has significant limitations in capturing the economic costs of events. Accurate cost data typically require cadastral information or continuous monitoring, resources generally available only to government entities or specialized institutions with the necessary technical capacity. Consequently, many records, especially from developing countries, remain incomplete, resulting in an underestimation of true direct costs. In fact, approximately 68.5% of EMDAT entries in our dataset lacked sufficient cost information, with particularly high rates of missing data in regions such as Sub-Saharan Africa (92.44%) and Northern Africa (82.42%). Because there was no adequate sample size by event type or subregion to perform an imputation, these entries were excluded from the final sum and no imputation methods were applied. While this step was necessary for data quality, it may further contribute to underestimating the overall costs of disasters.

   a. In addition, EM-DAT is known to have a systemic bias toward developed countries, where disaster reporting mechanisms are more robust. In contrast, developing regions, particularly in Sub-Saharan Africa, Northern Africa, and other low-income areas, often lack the institutional capacity and resources needed for comprehensive disaster data collection. This bias not only results in underreporting of disaster events in developing regions but also likely leads to an underestimation of the associated economic costs. As a result, global assessments may overrepresent losses in developed economies while underestimating both the frequency and severity of disasters in developing countries. Future research should explore integrating alternative data sources, such as local government records, remote-sensing data, or datasets from institutions like the World Bank, and developing robust imputation methods to fill these data gaps and improve the accuracy of disaster cost estimates.

   b. The current data emphasize large-scale, sudden-onset disasters, potentially overlooking small-scale or slow-onset events (e.g., droughts, land degradation), leading to an imbalanced understanding of overall risk.

2. The Desinventar database is based on data provided and validated by member countries. Since these countries may either not provide complete information or may deliver data inconsistently, inherent biases can arise, which may affect the reliability of the information. Another shortcoming is that many Desinventar databases are outdated, with no recent updates in some cases, further limiting the coverage and accuracy of the dataset.

3. While using GDP per capita to approximate the economic costs of disaster-related deaths provides a convenient baseline, several important limitations must be acknowledged. First, the absence of age differentiation may underestimate long-term impacts, particularly when younger individuals, who have more potential years of productivity, are lost. Second, focusing solely on measurable economic productivity overlooks significant but often invisible contributions to household labor and social well-being. Finally, GDP itself does not fully capture the broader social and economic consequences of disaster-related deaths, which can include psychological effects, shifts in family dynamics, and other intangible costs that extend well beyond direct financial losses.

4. In estimating the cost associated with disaster-related deaths, we recognize that more specialized methodologies, such as Disability-Adjusted Life Years (DALYs) adapted for disasters, the Value of a Statistical Life (VSL), or the Human Capital (HC) approach, could potentially offer more refined assessments. However, comprehensive, standardized datasets applying these methods to historical, multi-country disaster data are not yet widely available. Organizations such as the OECD and WHO are actively working on developing these frameworks, but in the interim, using GDP per capita provides a consistent, broadly applicable proxy that enables cross-country comparisons. Future research may incorporate DALYs for disasters, VSL, or HC approaches once more robust and universally accepted datasets become accessible.

5. During this study, we consulted with experts from the World Bank regarding the incorporation of well-being costs. While these metrics can shed light on how disasters disproportionately affect vulnerable populations, by measuring broader social and psychological impacts, they do not represent actual expenditures. Consequently, combining them with direct monetary losses can lead to conceptual inconsistencies and the risk of double counting. After considering these factors, as well as feedback from the World Bank, we decided not to include well-being costs in our final estimates. Nonetheless, recognizing their importance underscores the need for future research and more refined methodologies to capture the full spectrum of disaster impacts.

6. Due to the absence of precise annual cost data for some of the metrics mentioned, an approximation was made using the growth rate of affected populations. This approach aimed to dynamically account for changes in both environmental conditions and disaster impacts. It is important to note, however, that this represents a significant hypothesis within the debate, as it is challenging to definitively establish a direct correlation between environmental impact and the rate of affected populations.

7. In addition to direct physical damage, disasters often impose extensive indirect costs, such as business interruptions, infrastructure shutdowns, and supply chain disruptions, that are not consistently reflected in existing databases. These factors can lead to prolonged downtime, reduced productivity, and lost revenue, disproportionately affecting small businesses, vulnerable communities, subsistence farmers, and the informal economy, which is frequently omitted from formal assessments. Moreover, many intangible or harder-to-measure impacts, like ecosystem degradation, and long-term declines in economic output, are also overlooked in standard cost evaluations. As a result, conventional figures on disaster losses may underestimate the true scope of impacts. Recognizing and quantifying these broader repercussions is critical for designing effective risk reduction strategies, guiding more accurate resource allocation, and ensuring that post-disaster recovery efforts address not just visible damages but also the cascading effects on livelihoods and well-being.

8. The Kotz et al. damage function, while valuable for projecting climate-related economic damages, has several modeling constraints. Its limited lag structure may underestimate how long disaster impacts persist in the economy, and its reliance on historical relationships may not hold under future climate conditions, where nonlinear modeling approaches could better capture shifting economic responses. The model also assumes largely static socio-economic conditions, overlooking the potential for adaptive measures, such as infrastructure upgrades or policy reforms, to mitigate risks. Moreover, tipping points and nonlinear effects are not explicitly modeled, potentially underestimating the magnitude of abrupt or extreme climate shocks. A lack of sectoral detail further reduces the model's ability to generate policy-relevant insights for industries most vulnerable to climate change, while global interconnections like supply chain disruptions and migration flows remain insufficiently captured.

In conclusion, while the methodologies employed provide a framework for understanding the cascading economic and societal impacts of disasters, they also highlight the need for further research and improved data collection. Enhanced methods are essential for fully capturing the true costs of disasters, thereby informing more effective policy responses and mitigation strategies.

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