MarshMcLennan

Staying above water: A systemic response to rising flood risk

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Contents

Executive Summary

Flooding is no longer a localized challenge, but a systemic, global threat.

Flood risk is increasing at an alarming rate in many parts of the world. More frequent and severe floods pose an increasing, complex threat to society, economic activity, and the environment. Risk levels are amplified by climate change, nature loss, and the concentration of people and assets in flood-prone areas.

Sea level rise is worsening the impact of storm surges in some coastal regions, while changing climate patterns are also increasing flooding outside traditional risk zones, for example, through record-breaking rainfall events.

Global economic losses from floods increased from $504 billion in the 15 years between 1992 and 2006 to $729 billion between 2007 and 2021 (in inflation-adjusted 2021 dollars).

The global population threatened by flooding is expected to rise from 18% now, to 36% in a 2°C warming scenario, to 45% under a 3.5°C warming scenario.

Flood insurance protection gaps are growing in many parts of the world. Losses are leading to challenging renewals and insurers exiting markets. In many countries, flood insurance is not even available.

Flooding creates significant social costs. Floods exacerbate inequalities, reverse development gains, and cause large-scale population displacements. With expected sea level rises these social costs could multiply, as up to 630 million people will live on land below projected annual flood levels by the end of this century.

Conventional strategies and incremental approaches are insufficient to address rapidly changing risk levels. Flood risk management and resilience are rendered ineffective by the short-term thinking of decision-makers, limited stakeholder collaboration, misaligned incentives, and unsuccessful financing models.

The main shortcomings of current approaches include:

- *Not recognizing that, how and why risk levels are changing:* Following an outdated paradigm of protection, society is overwhelmed by "off the chart" disasters.
- *Building in the wrong places:* The concentration of property and economic activities in high-risk areas is growing fast, while future risk levels are often ignored or underestimated.
- *Continuous environmental degradation:* Loss of nature — including the disappearance of coastal mangrove forests and coral reefs — increases flood risk.
- *Improper agricultural practices:* Agriculture often encroaches on natural flood buffer zones and increases flood risk by altering soil structure and water retention capacity.
- *Aging flood risk management infrastructure:* Urgent upgrades of existing drainage and flood protection measures are needed.
- *Underfunding and inefficient implementation of risk management strategies:* Many flood risk management tools are underutilized or unavailable to those most at risk.

Transforming flood risk management is critical. The scale and complexity of this challenge requires: deploying solutions in a forward-looking, cross-cutting, and collaborative manner; tackling the underlying risk drivers; and framing flood risk management as an investment opportunity.

Not everyone can be protected, insured, or bailed out. Society needs to be realistic about the limits and costs of flood risk management.

To accelerate the transformation of flood risk management, we present three ways forward. For each, we define the rationale and vision, outline the core components, and provide examples of implementation. In many locations, all three ways forward should be integrated into flood resilience strategies.

1. **Learning to live with floods.** Society must expect and prepare for flooding, with responses that enable a return to normal with minimal disruption after low-level, low-intensity floods. This means adapting to changing risk levels in a timely manner. Risk culture must balance fairness and individual responsibility. Risk data should be used effectively and knowledge translated into action. Community engagement initiatives should cultivate a culture of shared risk ownership, while innovative technologies link early warning to early action, and insurance solutions incentivize risk reduction.
2. **Building strategic protection.** Destructive, tail risk events still require protection, particularly for essential assets and locations where moving is not an option. In this instance, water is a design driver for urban development, while society increases investments in preserving ecosystems. Funding comes through innovative financial mechanisms that monetize resilience for investors and provide attractive returns. Standardized frameworks help investors measure resilience, and resilience assessments from rating agencies steer private sector investments. New risk finance pools for communities provide insurance and resilience finance. Investments in data and technology support schemes such as resilience bonds, while risk reduction makes it possible to extend insurance coverage through solutions such as resilience-focused, public-private risk pools.
3. **Preparing for relocation.** In high-risk locations, it may not be feasible to accommodate floods or build protection. Planned relocations of people and assets can be both economically efficient and equitable. Here, risk assessments serve as the basis for action, and countries lay the foundations for relocations early with anticipatory governance and long-term funding arrangements. Communities are empowered to contribute to decisions on acceptable levels of risk, identifying priorities such as cultural preservation. Mechanisms to redirect resources from disaster relief to pre-emptive buyouts enable societies to avoid a pattern of cyclical destruction and rebuilding. In countries with space constraints, relocations take place across borders and are governed by international agreements. New financing and funding mechanisms based on long-term cost minimization and distributional fairness are deployed at scale.

Bold steps from governments and the private sector are needed if society is to shift from a reactive to a proactive approach to flood resilience. Strong narratives about co-benefits are essential. Similarly, decision makers must be prepared to confront difficult trade-offs.

Key actions that can be taken now to overcome inertia and mobilize stakeholders include:

- **Build a risk culture that balances fairness and individual responsibility** by integrating resilience measures into existing risk models. An immediate priority is to replace protection goals with resilience objectives and a set of rules that do not shield stakeholders from the consequences of their risky decisions.
- **Transform land use and infrastructure planning** by switching to innovative mechanisms that ensure the enforcement of building standards, establish statutory requirements for combining green and gray infrastructure, and offer financial incentives for rural land management.
- **Mobilize financial capital for flood resilience** by standardizing co-benefit assessments and integrating them into environmental, social, and governance (ESG) and green finance frameworks. This also can be incentivized by strengthening the role of resilience ratings in awarding public and private contracts.
- **Shift to a resilience-focused insurance system** by removing regulatory barriers and creating innovative insurance models. This can be accomplished through building back better principles or community-based catastrophe insurance (CBCI) that create financial incentives for resilience interventions.

Introduction

Society must urgently transform its response to flood risk. Despite decades of efforts aimed at controlling floods, losses have been rising. Conventional strategies and incremental approaches remain insufficient to address changing risk levels, with flood risk management intent on crisis response rather than prevention and lacking a long-term focus on resilience.

The interplay of flooding with other risk drivers has increased its impacts and complexity. Communities have often settled along coasts or near bodies of water for economic purposes. In doing so, societies have long encroached on waterways, reclaimed land for agriculture, and built over rivers. This process has accelerated significantly in recent decades due to urbanization and population growth. Fueled by climate change and nature loss, the challenge has increased dramatically.

A recent series of catastrophic flooding incidents heralds a new era of disasters. In New Zealand, deadly floods caused by Cyclone Gabrielle in February 2023 came just weeks after multiple locations in the North Island experienced their worst floods on record. Battered by consecutive extreme weather events, the country declared a state of national emergency for the third time in its history.[1] In California, heavy rainfall, four times above average, caused month-long floods between December 2022 and January 2023.[2] Roads, levees, and power networks were destroyed, threatening the lives of millions. The United States also witnessed record-breaking coastal flooding caused by Hurricane Ian in September 2022, leading to extensive destruction and incurring losses worth billions of dollars.[3] The same month, Japan was hit by Typhoon Nanmadol, which unleashed disastrous floods in the south-west and forced officials to evacuate 9 million people;[4] economic activity came to a halt, with power disruptions to thousands of households, the suspension of public transport and flights, and the closure of manufacturing operations.[5] In Pakistan, melting glaciers from extreme heat combined with monsoon rains to cause unprecedented flooding that devastated large parts of the country from July to October.[6] At more than 1,700 casualties, it was the deadliest event in 2022. In Australia, flooding events throughout the year devastated communities and overwhelmed emergency services;[7] rainfall in the eastern coast of Australia caused rivers to overrun across the Murray-Darling basin system, resulting in extensive flooding in southern and western Australia.[8]

But recent events were not exceptions: Previous years were also marked by catastrophe. In the United Kingdom, flash floods in London in July 2021 overwhelmed the city's Victorian era drainage systems in a little over an hour, causing sewers to overflow.[9] That same week, excessive rainfall triggered deadly floods in the Netherlands, Belgium, and Germany, leaving a trail of devastation to communities and transport infrastructure (particularly in the Ahr Valley).[10] In China, the June 2020 floods were the worst in decades, affecting over 63 million people, causing $29 billion in economic losses, and damaging 76 cultural heritage sites.[11,12]

All these events highlight how the threat of flooding is escalating while efforts to manage risks remain inadequate. Additionally, flood insurance protection gaps are growing in many parts of the world. Losses are leaving a mark on the sector and led to a particularly challenging 1 January 2023 renewal in some key markets, while in many countries flood insurance is still not available.

Bold steps are needed if society is to shift from a reactive to a proactive approach to flood resilience.

Underpinned by data from the *Marsh McLennan Flood Risk Index*, *Staying Above Water: A Systemic Response to Rising Flood Risk* discusses risk drivers, impacts, and the inadequacies of current risk management strategies, making a strong case for action. The report also sets out principles for resilience and a vision for transforming flood risk management along three ways forward: Living with floods, building strategic protection, and preparing for relocation. Examples of innovative strategies from different socioeconomic contexts and geographies illustrate how the transformation can be realized. The report concludes with a call to action, proposing concrete steps to overcome inertia and mobilize stakeholders.

This report is the latest output in the *Rethinking Flood* series, following *Sunk Costs: The Socioeconomic Impacts of Flooding* and *Preparing for a Wetter World: Strategies for Corporate Flood Resilience.*

In this report, resilience is framed in a strategic manner, considering system- and asset-level responses to changing risks by integrating the need to accommodate, protect, and retreat.

The urgency to act

Flood risk is increasing at an alarming rate, posing growing complex threats to people, assets, and the environment. Its impacts cascade across socioeconomic and financial systems, pushing society ever closer to dangerous tipping points.

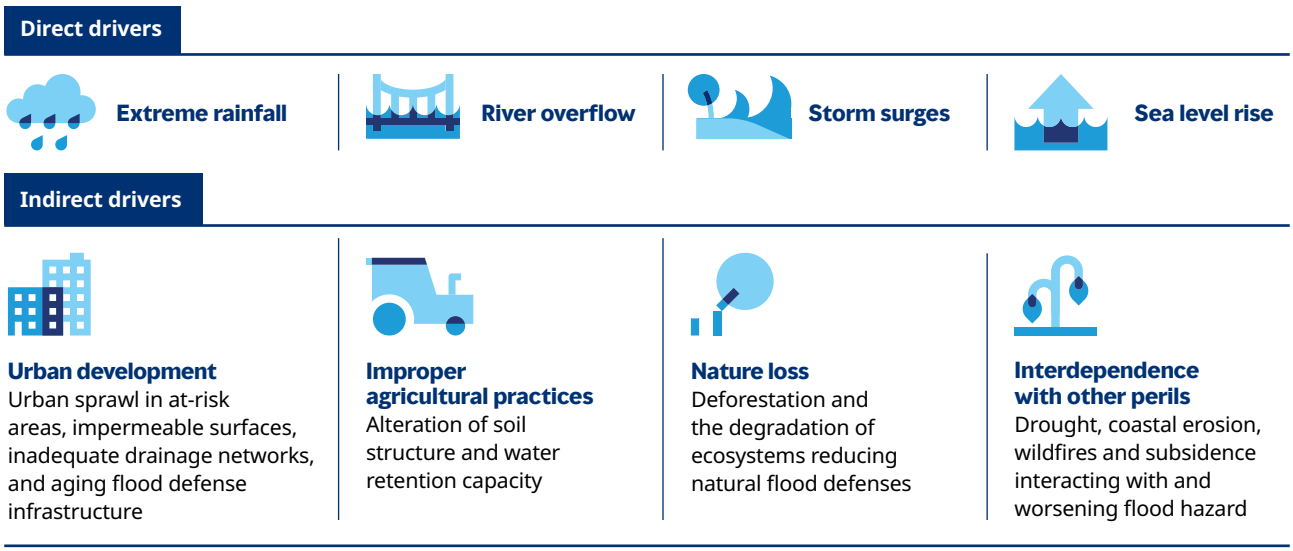
Never before has society had a clearer picture of the scale and complexity of the challenges brought by flooding. The effects of climate change and nature loss, and the rising concentration of people and assets in flood-prone areas drive risk levels higher and create cascading impacts across systems. With this knowledge comes a clear urgency for governments, businesses, and communities to increase preparedness and resilience.

Multiple interconnected risk drivers are at play

Interlinked physical and socioeconomic factors influence the severity and frequency of flooding (see Exhibit 1). Underpinning these drivers is climate change, with extreme weather, warming temperatures, and rising sea levels amplifying the threat of flooding.[13] Climate change is also worsening indirect drivers of flood risk such as nature loss and coastal erosion.

At the same time, the continual build-up of communities and economic activity in at-risk areas is exposing more people and assets to floods.[14] In many countries, the concentration of property and activities in high-risk urban areas, such as low-lying coastal zones, is growing faster than in less risky areas. These trends are further aggravated by aging flood control infrastructure and outdated drainage networks, which are already unable to cope with today's risk levels.

Exhibit 1: Direct and indirect drivers of flood risk



Climate change influences direct and indirect drivers and amplifies flood risk

Source: Marsh McLennan

Agriculture also plays a role in fueling flood risk. Nearly half of the world's habitable land is taken up by agriculture, a percentage expected to increase as population growth continues to strain food production.[15] Besides encroaching on natural flood buffer zones, many agricultural practices, such as the poor choice of crops, soil cultivation by heavy machinery, and farming steep slopes for maize, can significantly exacerbate flood risk by increasing water runoff.[16]

In many parts of the world, environmental degradation and flooding feed into each other. For example, deforestation in West Africa was shown to increase

surface air temperatures, causing a doubling in the frequency of thunderstorms.[17] Biodiversity loss can also intensify flooding, which leads to further degradation of ecosystems through erosion, pollution, and sedimentation. In particular, the loss of coastal mangrove forests and coral reefs has reduced natural buffers against rising sea levels and storm surges. In the United States, a reduction of coral reef heights by one meter would cause a 62% rise in the number of people at risk of coastal flooding, along with a 90% rise in assets at risk, leading to an estimated $5.3 billion increase in damages annually.[18]

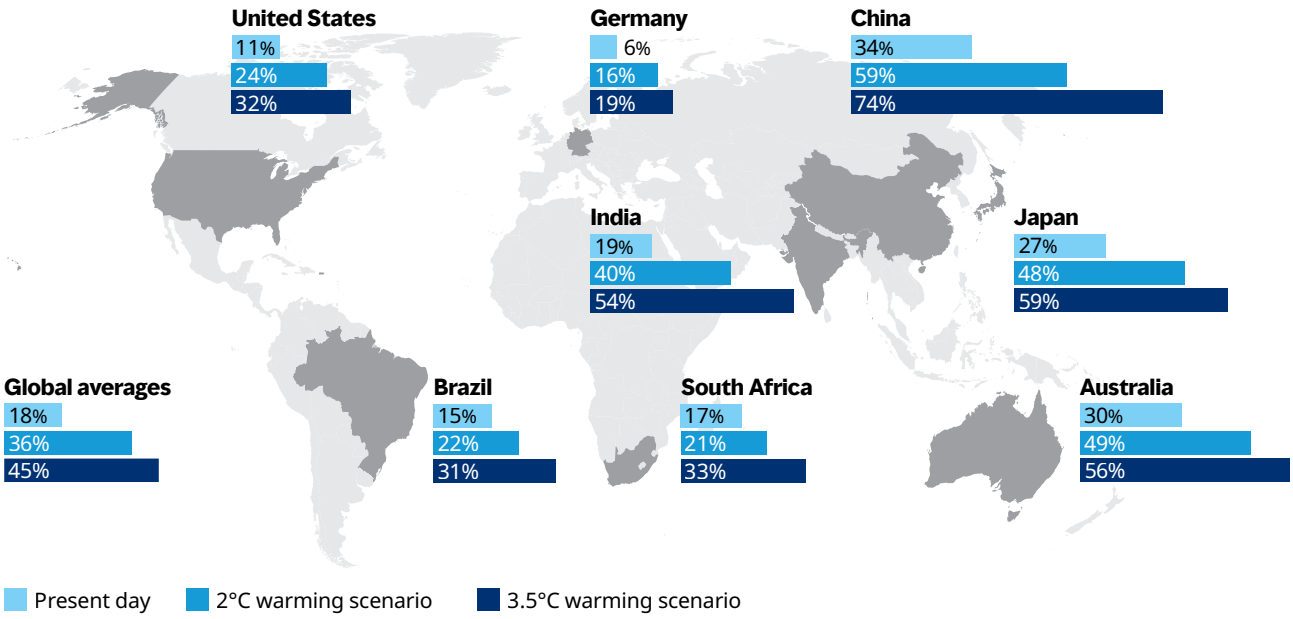
Another multiplier effect is evident in the interplay between floods and other perils, often altering landscapes and ecosystems permanently. For example, coastal flooding — whose effects are often exacerbated by subsidence — accelerates shoreline erosion, which in turn amplifies the impact of storm surges, high tides, and sea level rise.[19] Similarly, the intensification of the hydrologic cycle caused by climate change creates a feedback loop where floods and droughts aggravate one another.[20] Wildfires can also increase flood risk by leaving behind barren terrain incapable of absorbing rainfall. This has been recently observed in California, where burned areas were severely impacted by flash floods.[21]

Escalating impacts across socioeconomic systems

Global economic losses from floods have been on the rise, increasing from $504 billion in the 15-year period between 1992 and 2006 to $729 billion between 2007 and 2021 (inflation-adjusted 2021 dollars).[22] Only 17% of global losses were insured between 2007 and 2021, with the biggest protection gaps in developing countries, where insurance is often not available. Even in emerging markets, only 5% of economic losses from floods over the past 10 years were insured, compared with 34% in developed economies.[23]

According to Marsh McLennan estimates, 18% of the global population is currently threatened by flooding. Limiting global warming to 2°C would cause this percentage to double to 36%, while under a 3.5°C warming scenario 45% of the world's population would be at risk (see Exhibit 2). The danger of flooding will be particularly severe in coastal areas, with many shoreline communities already facing an existential threat. By 2050, 570 coastal cities with a total population of more than 800 million people are expected to be impacted by sea level rise.[24]

Exhibit 2: Population at risk at present and under 2°C and 3.5°C warming scenarios



Source: Marsh McLennan

The *Marsh McLennan Flood Risk Index* also shows how the impacts of flooding on infrastructure are already visible and set to grow over time, with power plants, international airports, and international ports under strain (see Exhibit 3). This underlines that, in addition to the direct effects on populations and assets, flooding is a risk multiplier, triggering cascading impacts across socioeconomic systems: Disruptions propagating through supply and value chains compound direct damage, with countries, communities, and businesses not physically exposed to floods still suffering from indirect impacts.

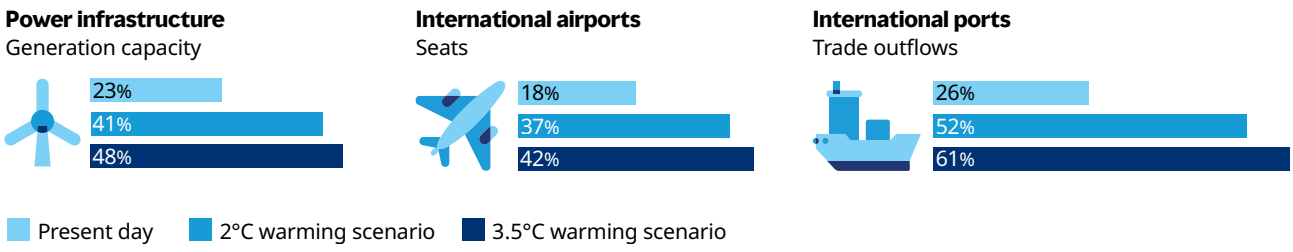
Central banks have highlighted the potential for flood damage to destabilize financial systems, especially in light of the rising protection gap and the possible uninsurability of high-risk assets and communities.[25] With substantial loans to households and businesses in flood-prone areas, indirect impacts of flooding, such as the abrupt repricing of assets, credit losses, and rising mortgage defaults, can propagate through financial systems and threaten their stability. In the United States, for example, residential properties in at-risk areas were found to be overvalued by $121 billion to $237 billion due to unpriced flood risk.[26]

Moreover, the spillover impacts of flooding pose huge social costs: Floods exacerbate inequalities within and across countries, often deepening socioeconomic and racial fault lines and reversing development gains. Recent events have demonstrated that flood impacts are disproportionately borne by the most vulnerable, resulting in these groups being locked into poverty traps. In both high- and low-income countries, the emergence of "flood ghettos" is already a reality, with poor and vulnerable parts of the population priced out of better protected or better managed areas.

Flooding is also set to cause large-scale population displacements, with estimates of sea level rise indicating that up to 630 million people worldwide will live on land below projected annual flood levels by the end of the century.[27]

With these wide-ranging implications, flood events have the potential to exacerbate the impact of other crises, such as pandemics, political instability, and resource conflicts. These polycrises tend to leave societies with little to no room to recover.[28]

Exhibit 3: Infrastructure at risk at present and under 2°C and 3.5°C warming scenarios



Source: Marsh McLennan Flood Risk Index

The inadequacy of current strategies

Risk levels are outpacing society's ability to handle catastrophic events, with current approaches no longer sufficient. High-income and low-income countries alike struggle to cope with today's levels of risk, let alone change the resilience trajectories of communities, businesses, and governments.

Current flood risk management strategies are not keeping pace with growing risk levels. They focus on recovery rather than prevention and are built on outdated paradigms of protection. This leads to maladaptation, costly lock-ins, and chronic underinvestment in resilience.

Responsibility for flood risk management is heavily skewed towards the public sector, which continues to operate in a reactive "crisis-management" mode.

While some regions have made gradual progress beyond this paradigm, growing losses in recent years have exposed deficiencies in flood risk management strategies. Although the challenges vary, there are several failures that apply across socioeconomic contexts and geographies. The most critical ones can be categorized under three pillars: Governance, land use and infrastructure, and finance (see Exhibit 4).

Exhibit 4: Examples of common failures in flood risk management

GOVERNANCE	LAND USE AND INFRASTRUCTURE	FINANCE
• Failure to account for changing risk levels • Limited appreciation of socioeconomic implications • Ineffective incentive systems	• Permitted maladaptation and continued risk creation • Overreliance on gray infrastructure and underinvestment in nature-based solutions • Inadequate infrastructure maintenance efforts	• Disruption to insurers' business models and reduced access to coverage • Challenges in persistent lack of resilience measurement and indicators • Chronic underinvestment in risk reduction and preparedness

Source: Marsh McLennan

Governance failures

Resilience as a concept is recognized by public and private decision-makers, but targeted action has been hindered by ineffective stakeholder collaboration, bureaucratic inertia, and the lack of political will to invest in transformative, long-term strategies. Furthermore, when policies are implemented without aligning incentives, they have the effect of increasing flood risk and placing a disproportionate burden of responsibility on the government.

Flood risk management strategies do not adequately consider changing flood risk levels

Decision-making processes are predominantly geared towards the concerns of today or the near term. While the tragedy of the horizon is well recognized,[29] its implications for flood risk management are often overlooked: Strategies fail to account for evolving risk levels over the lifetime of assets, leading to risky development decisions that amplify vulnerabilities and cause lock-ins. According to a national flood risk assessment in the United States, the Federal Emergency Management Agency's flood maps were found to have underestimated the number of properties at risk by 67%.[30] This translates into an additional 8 million properties at risk of flooding that were not accounted for in the national maps. Despite the availability of better modelling tools, decisions are made based on historical risk patterns, and authorities tend to be overwhelmed by "off the chart" disasters. There is the danger of misinterpreting climate change as a gradual process. Ignoring sudden shifts and non-linear consequences and not accounting for uncertainties limits the effectiveness of risk management strategies.

Lack of understanding of the socioeconomic implications of flooding results in the execution of poorly coordinated strategies

Risk management approaches often fail to integrate broader resilience objectives, such as economic growth plans, urban regeneration projects, poverty alleviation schemes, or environmental protection initiatives. Early integration offers wider co-benefits of flood resilience; however, prevailing silo mentalities within organizations hamper the adoption of a systems view and lead to fragmented responsibilities, conflicting objectives, the exclusion of critical stakeholders, or ineffective coordination across sectors and levels of government. This results in maladaptation, delays, and gaps in protection. For example, the 2021 floods in Germany exposed coordination challenges that stemmed from a failure to adequately consider the wide-ranging impacts of the event.[31] Flooding damaged critical communication infrastructure, leaving unprepared first responders to use digital radios that were incompatible with one another. Authorities underestimated the extent of contamination from heating oil and sewage on properties, hampering rebuilding efforts. A decade earlier, the 2011 Thai floods demonstrated how poorly governed strategies can amplify risks and prolong disruption.[32] The country's fragmented water management structure, involving 16 organizations, faced several coordination challenges in planning upstream water management, compounding flood impacts for downstream communities and businesses.[33] Coordination inefficiencies among local authorities resulted in delays in restoring critical infrastructure in industrial parks, prolonging business interruptions and disruptions to global supply chains.

Inefficient incentive systems that place the government as a savior lead to prevailing complacency

Policies meant to tackle flood risk can create perverse incentives, thereby amplifying rather than reducing flood threats. Risk-blind or heavily subsidized national flood insurance premiums put in place to ensure affordability of insurance can lead to an underestimation of risk, amplify moral hazard, and crowd out private insurers. In fact, a quarter of all claims paid by the debt-ridden National Flood Insurance Program (NFIP) in the United States have been for "repetitive loss properties" — defined as those that are repeatedly damaged by flooding and qualify for claims of more than US$1000 in any 10-year period since 1978.[34] In an extreme but telling case, a US$69,000 house in Mississippi has flooded 34 times in 32 years, accruing US$663,000 in NFIP claims.

Similarly, if not calibrated correctly, crisis assistance and infrastructure policies can discourage the recognition of shared responsibilities. Disaster relief programs incentivize homeowners to rebuild in at-risk areas. As the cost of the hazard is shifted to the government, households, businesses, and communities are disincentivized from taking actions to enhance preparedness. Large-scale public flood defense projects can also lead to a false sense of security: Virtually no intervention to limit physical risk can reduce it to zero, but policymakers, businesses, and residents may consider the flood problem "to be solved" by a new river defense mechanism, removing any interest or incentives for additional flood resilience measures such as protection against surface water flooding.[35]

Ineffective incentive systems dilute the creation of shared risk ownership and contribute to poor risk awareness among the public. Findings from a national survey in Canada revealed shocking gaps in risk awareness — only 6% of respondents living in flood-prone areas knew that they were at risk, and nearly half of the respondents reported being unconcerned about flooding.[36]

Land use and infrastructure challenges

Competing financial and political priorities in land-use and property development can encourage the development of flood-prone areas. Locating new development in at-risk areas creates additional pressure on flood protection infrastructure, amplifying the chance of failure. Moreover, flood risk management strategies are often dominated by gray infrastructural defenses such as floodwalls, floodgates, levees, and dikes, whose limits in offering protection over time are not sufficiently acknowledged.

Permitted maladaptation due to conflicting objectives for land use and development exacerbates risks

Too often, decisions on where to build and on land use lead to risky development. This can be due to many reasons, including lack of information about risk levels, disputes over flood maps, and zoning driven by short-term political and financial motivations, such as the local authorities' need for increased tax revenue from new building projects. These factors can disincentivize the enforcement of regulations or prevent the adoption of effective land use policies. In other cases, planning officials are ill-equipped, understaffed, and lack the time and resources to monitor compliance. Particularly in developing countries, fast-paced urbanization and limited oversight have led to maladaptation, such as creating inadequate urban drainage systems and erecting unapproved structures in flood-prone areas, which obstruct the natural flow of water.

An overreliance on gray flood control infrastructure compounds physical and financial vulnerabilities

Gray defense infrastructure requires high levels of investment in maintenance and repair, and often lacks the flexibility to be upgraded in a timely and cost-efficient way. Heavily relying on gray infrastructure without recognizing its limitations can be costly and have adverse effects. In the United States, a $14 billion rebuilt network of levees in New Orleans after Hurricane Katrina in 2005 is expected to stop providing adequate protection by 2023, requiring hundreds of millions of dollars in additional investments.[37] In South Korea, the world's longest seawall, costing nearly $3 billion, has caused adverse environmental impacts such as the destruction of coastal wetlands and a dramatic decline in biodiversity.[38] Often, gray infrastructure is treated as a standalone flood protection solution and is not well integrated into wider flood risk management measures, such as nature-based protections.

Inadequate maintenance of an aging infrastructure heightens the risks of failure

Maintenance of critical flood control infrastructure is often lacking, amplifying the risk of failure and damage. Infrastructure collapses can prolong disruption and amplify the human and economic costs of flooding. While typically viewed as an issue in developing countries, neglected flood protection infrastructure is often the case in high-income countries. In the United States, 1,688 dams were rated in poor or unsatisfactory condition as of 2019, and there have been 250 dam failures since 2010.[39] Around 15% of dams have been classified as having "high hazard potential" based on the potential impacts of dam failure or misoperation. Between 2000 and 2020, the number of dams with high hazard potential has more than doubled.[40]

Every dollar spent on flood risk reduction leads to a savings of five dollars.

Financial constraints

Short-term financial returns are often favored over long-term investments in resilience, preventing the implementation of risk reduction measures. Given rising costs, public funds alone are insufficient to support the implementation of resilience strategies. Yet, despite a strong benefit-cost ratio, most resilience measures are unattractive to public and private investors due to unclear revenue streams. Insurance, a critical component in the financial management of flood risks, is faced with progressively deteriorating challenges that further erode resilience.

Insufficient pre-event funding and chronic levels of underinvestment amplify the financing gap

Investing in flood resilience is cost effective: Every dollar spent on flood risk reduction leads to a savings of five dollars.[41] Yet, the discrepancy

between preparedness and response funding remains stark. In the United States, the allocation of funds to pre-disaster mitigation efforts stands at only 6% of the total natural catastrophe spending under the Disaster Relief Fund, the single largest source of federal disaster spending.[42] Efforts to channel alternative sources of funds have been limited as flood resilience has not yet become an attractive investment proposition for private investors, with mechanisms to effectively harness private sector funding remaining underdeveloped.

In an increasingly interconnected risk landscape, the costs of recovery from flooding are becoming unsustainable. Increasing government expenditure on crisis assistance may result in worsening budgetary pressures, especially in less wealthy countries. The 2022 floods in Pakistan inflicted more than $30 billion in damages and economic losses, exacerbating the country's debt crisis.[43] The price of inaction is clear: Cost-benefit ratios of flood risk management decrease once risks are too high, and funds needed for flood resilience will continue to rise exponentially. This further complicates countries' ability to balance investments in climate adaptation, preparedness, and recovery.

Measuring progress toward resilience goals and estimating the advantages brought by resilience measures is often challenging

There are very few standardized metrics and frameworks for assessing flood risk resilience, making it challenging to track progress or demonstrate performance. This makes it difficult to compare resilience levels across communities, countries, or sectors. The absence of clear metrics also hampers the quantification of averted losses and of socioeconomic and environmental co-benefits. Moreover, some of these dividends may only materialize in the long term, making it hard to accurately determine progress. As a consequence, the underestimation of resilience benefits offered by interventions can hinder action or lead to the adoption of measures that only prove effective in the short term.

Rising flood risk poses new challenges to insurers' business models and reduces access to coverage

Flood insurance is not available in all geographies, and where it exists, it tends to be underutilized and not designed for changing risk levels. Significant protection gaps exist, even in mature insurance markets (see Exhibit 5 on the next page). Asia has the largest flood protection gap in the world, and rapid population growth and economic growth are exacerbating the challenges in closing the gap.[44] In such regions, many insurers lack the analytical tools and data on hazard levels and historical losses needed to assess risk, causing a mismatch between their technical and financial capacities.

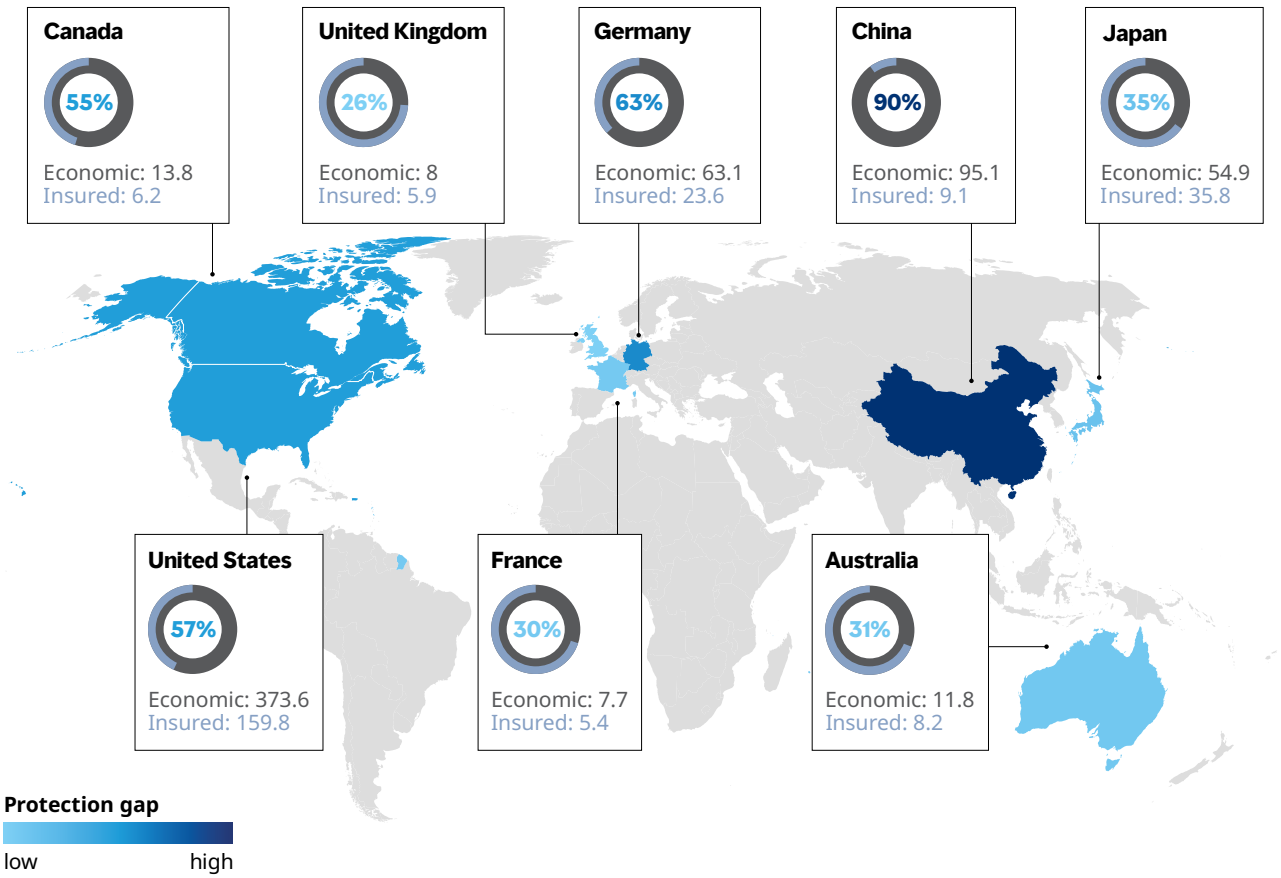
Access to insurance can be limited due to affordability problems, especially in low-income countries.[45] This is also of concern in mature markets, where premium hikes are common in the face of losses and mounting risks. For example, in northern Australia, disasters triggered price hikes of over 200% for building only insurance between 2007 and 2022, compared to around 120% for the rest of the country.[46] Changing risk levels can also discourage reinsurers from offering cover. The Task Force on Climate-Related Financial Disclosures (TCFD) reports from leading insurers describe the impacts of climate change on their financial exposures. These documents reveal that growing levels of catastrophe accumulation and volatility are discouraging some insurers from covering flood risks, while others are planning to adopt tighter underwriting strategies or to withdraw from certain geographies entirely.

This is already a reality in Florida, where recurrent catastrophes amplify challenges for the state's volatile property insurance industry. Private insurers have begun to withdraw from the homeowner market, and some smaller insurers have been forced into insolvency.[47] In Australia, the number of uninsurable properties in the country will grow by 24% in the next 30 years, with 1 in 25 buildings not having access to coverage.[48]

The insurability crisis is expected to have the strongest impact on vulnerable segments of the population, who disproportionately reside in high-risk areas and are least capable of affording coverage. Compounding this problem is the lack of risk transfer tools and policies to protect low-income households. In the United States, more than 425,000 people discontinued their policies under the National Flood Insurance Program (NFIP) after premiums were revised under Risk Rating 2.0.[49]

The common 12-month underwriting cycle provides flexibility to insurers and reinsurers as it enables a regular review of insurability, pricing, and market appetite for risks and geographies. While this increases the sector's resilience in the face of rising risks, it also means that cover provided by the private sector cannot be taken for granted and that regulatory and policy interventions must address the protection gap.

Exhibit 5: Map showing cumulative flood losses (US $ billions) and protection gaps across select countries between 2012 and 2021



Note: Economic and insured loss data for the United States includes tropical cyclones; data for China and Japan includes floods and tropical cyclones; data for France, Germany, and Canada includes floods and severe convective storms; data for Australia includes floods, tropical cyclones, and severe convective storms

Source: Swiss Re

The transformation of flood risk management

Transforming flood risk management requires the use of tools in a forward-looking, cross-cutting, and collaborative manner. For this to succeed, society must demonstrate vision, moving beyond unsustainable paradigms of protection towards a balance between addressing acute crises and fostering long-term resilience.

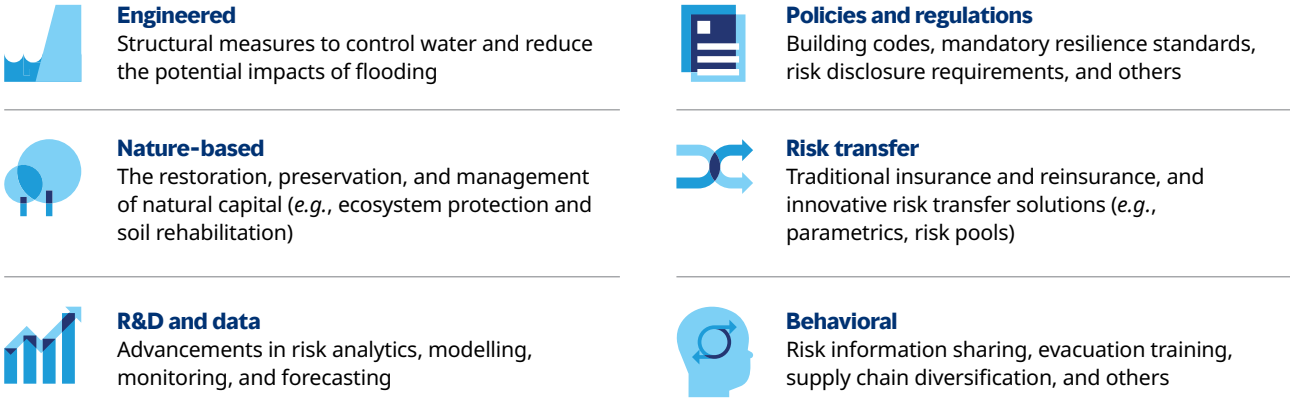
This is a pivotal moment to reimagine flood risk management. As reported in the *Global Risks Report 2023*, stakeholders must balance their responses to current crises with a longer-term focus on building resilience.[50] Yet many decisions made today create risk pathways that will be difficult and costly to change and will render existing risk management options ineffective.

Rethinking the use of risk management tools

Transforming flood risk management requires tackling the underlying drivers of risk rather than just dealing with the symptoms. With better data and technologies to advance the analytical understanding of flood risk and a portfolio of risk management tools at disposal (see Exhibit 6), society can be equipped with unprecedented levels of knowledge and skills to act. These tools can be leveraged to activate the right enablers, avoid disincentives, avert lock-ins in unsustainable pathways, and prevent further risk generation.

However, many of these tools are underutilized, underfunded, or inefficiently implemented, while in developing countries, in particular, availability and affordability present key challenges. The application of these tools needs to be reimagined through innovative strategies, combining them effectively in response to local needs and requirements. At the same time, there needs to be clarity on the limits of these tools: Not everything can be protected, not all assets are insurable, and not all communities or locations are suitable for further development.

Exhibit 6: Portfolio of established and emerging tools to manage flood risk



Source: Marsh McLennan Flood Risk Index

To successfully transform flood risk management, it is essential to utilize any available tools in a forward-looking, systems-level, and coordinated manner. These three principles should guide the design of innovative strategies:

1. Embrace current and forward-looking risk trends

Risk levels are amplified by climate change and growing human and economic exposure. Flood risk management tools must be utilized in a forward-looking manner, calibrated to specific needs, and implemented with the intention of achieving a long-lasting impact. Data and models for climate change are available and need to be incorporated into decision-making. All risk management strategies must account for changing risk levels and uncertainties to avoid costly lock-ins. Taking a forward-looking approach allows societies to preempt difficult trade-offs, prioritize strategic investments, prevent blind

spots, and leave adequate buffers to switch strategies. This entails planning for multiple scenarios and adaptively modifying strategies in an iterative manner. By mapping different pathways and remaining agile, societies can anticipate points of failure for strategies and deploy tools appropriate for specific risk levels.

2. Harness co-benefits by taking a systems-level approach to resilience

Floods do not take place in isolation and have complex interdependencies with other crises. The interplay between floods and droughts, for example, requires an integrated water management strategy to harness floodwater effectively during times of water scarcity. Such a systems-level approach requires decision-makers to pay particular attention to interconnections between parts of systems. Analyzing and tackling the interdependencies can generate co-benefits. This is evident with nature-based solutions, which can offer advantages in the form of averted flood losses, economic benefits, and social and environmental dividends. Identifying co-benefits strengthens the business case for flood risk management. Presenting flood risk management as an investment opportunity, rather than a cost, is critical to expanding the financial capacity needed for scaling these tools.

3. Coordinate the implementation of tools through new modes of collaborations

Floods are a risk multiplier with spillover effects across socioeconomic ecosystems, countries, and supply chains. Reforming flood risk management calls for multifaceted and coordinated action from a diverse range of stakeholders, including businesses, households, communities, and governments. Too often, only a small snapshot of risks is assessed, and decisions are made in isolation due to narrowly defined roles and responsibilities. Active participation and extensive collaboration are crucial in unlocking the full benefits of these tools, with small-scale interventions adopted by households and communities complementing larger-scale interventions by governments or large corporations. Coordination across government layers and sectors is essential in minimizing externalities, such as in cases where interventions in one locality inadvertently lead to increased vulnerabilities in another. Enabling systemic changes to build resilience necessitates new modes of working, new forms of partnership, and new business models to align incentives. Stakeholder engagement is an important imperative, but it needs to be built around a systemic perspective, considering how the interactions of different actors can yield system-wide and sustainable results and how incentive structures can help avoid costly trade-offs.

Envisioning the transformation: Three ways forward

Reforming flood risk management requires a bold vision that resonates across stakeholder groups. A shared aim and objective can be supported by strong narratives — emphasizing the benefits of early action, but also being realistic about limits and costs. This bold vision revolves around three interdependent ways forward: Living with floods, building strategic protection, and preparing for relocation (see Exhibit 7 on the next page). Each interlinks and influences the others, and, in many locations, all three ways forward are needed: A push for resilience to enable society to live with floods should be complemented by investments in large-scale strategic protection to reduce the impact of catastrophic events. These interventions should be balanced by the need to relocate communities in areas where risk levels become intolerable.

Chapters 4, 5, and 6 describe a vision for each of the ways forward and introduce innovative strategies that have already been put into practice or are being planned. These examples can serve as models to help

society transform its approach to managing flood risk. However, defining such visions often plays out differently depending on the types of stakeholders involved as well as the geographic, socioeconomic, political, and cultural context. Similarly, strategies that may be transformative in one location simply may not be practical in another, while those that are already established by some businesses may appear radical to others.

Exhibit 7: Three ways forward to transform flood risk management

Source: Marsh McLennan

First way forward: Learning to live with floods

Government, businesses, and communities must prepare for flooding and accelerate recovery by building resilience to local, low-intensity events through coordinated interventions.

The threat of flooding cannot be reduced to zero: Complete protection of all communities and every property is neither technically possible nor economically efficient. Instead, strategies to reduce risks, limit damage, and facilitate recovery in the aftermath of flooding events are needed. To successfully live with floods, society must learn to expect and prepare for flooding and to respond and return to normality with minimal disruption. This means adapting to changing risk levels in a timely manner, rather than being surprised by "unprecedented" events such as record rainfall. At the heart of this is a risk culture that recognizes the different perceptions, values, attitudes, and beliefs of stakeholders and rewards those who make informed decisions. This chapter sets out the vision for this first way forward and presents examples of strategies that enable this vision.

Vision: Establishing a new risk culture

A strong risk culture with transparent and accessible information prevents the creation of a false sense of security and complacency. It is supported by clearly defined roles and responsibilities: Everyone who makes risk-relevant decisions is well informed and enabled to take responsibility for managing risks. New forms of meaningful coordination ensure that risk data is utilized effectively, and that this knowledge translates into action. Governments and regulators play a vital role in the coordination and initiation of risk management efforts. They provide the information needed for the successful implementation of resilience strategies and put in place the right financial and nonfinancial incentives, including subsidies, tax rebates, zoning laws, building standards, scientific and technical collaborations, and mandatory disclosures. The public and private sectors collaborate to ramp up investments in research and innovate flood forecasting and modelling. Data is shared with and collected from stakeholders across society, with actionable messages that increase awareness of flood risk and encourage resilience interventions.

Communities are informed and empowered to act on flood risk information. The far-reaching implications of floods are acknowledged, spurring society to transform its relationship with water. Flood risk is a topic that is embedded in school curricula, and society is no longer taken aback by catastrophic flooding incorrectly deemed "once-in-a-century" events. Community members actively partake in ground-up efforts to assess local vulnerabilities and devise tailored solutions to set them on a path to resilience. Historically marginalized communities are represented in these efforts, and solutions are implemented in an equitable manner to protect the most vulnerable and prevent the rise of flood risk ghettos.

Personal responsibility for flood risk management is well-recognized. Individuals consider resilience throughout the life cycle of their property and are disincentivized from owning property in risky areas and actively factor forward-looking information on flood risk into their purchasing decisions. To improve asset-level resilience and avoid maladaptation, a network of stakeholders, such as architects, developers, engineers, and insurers, are closely involved in the site selection and construction phases of projects. Investments in local-level flood mitigation infrastructure are widespread and understood as essential for ensuring the viability of communities, insurability, and prosperity. Evidence-backed property-level measures such as floodproofing are widely adopted at the point of design or when repairs are needed, and there is a broad understanding of their need and usefulness. For existing properties, owners plan comprehensively for retrofits, and implementation is coordinated with key phases of the building life cycle, such as annual maintenance needs. The competitive advantages of resilient buildings are widely acknowledged — they attract more tenants and have a higher resale value. Collaboration between real estate, insurers, lenders, and the public sector creates incentive structures that align the costs and benefits of resilience measures to better manage the upfront investments required to prepare for flooding.

Businesses implement resilience strategies at all levels of their operations, moving beyond simply preparing standard emergency response plans to working with suppliers and customers to strengthen their value chains and adapting business premises

to protect assets.[51] They leverage new analytical tools to anticipate how flood risk will evolve, quantify exposures, and design resilience strategies.

Financial institutions with in-depth risk management expertise, such as insurers, lenders, and investors, play a strategic role in mitigating flood risk. Insurance is redesigned and is geared towards enhancing recoverability and response times. Claims payouts are linked to the implementation of resilience measures, and there is recognition that insurance is one element of a much larger portfolio of tools to build resilience to floods. Parametric insurance solutions are utilized at scale to enable rapid payouts based on transparent criteria, with households and businesses receiving settlements within hours of the flooding event. Society can return to normal life with as little disruption as possible after low-level, low-intensity floods.

From vision to reality: Examples of innovative strategies

Community involvement in promoting resilience literacy and risk ownership

Community engagement initiatives are essential to cultivate a culture of shared risk ownership. The Zurich Flood Resilience Alliance, which operates in over 250 communities across the world, has developed a community flood resilience measurement tool with 44 indicators to guide community-based projects.[52] It applies a systemic view of resilience in terms of social, natural, physical, financial, and human capital, asking community stakeholders to score current levels of resilience and devise strategies to strengthen it.

Community engagement initiatives are essential to cultivate a culture of shared risk ownership.

In the United Kingdom, the Flood Resilience Community Pathfinder scheme connects communities with local partners to develop resilience plans.[53] Funding was granted to 13 local authorities in England. Some of the solutions proposed by the Pathfinder projects include local-level flood vulnerability assessments, the creation of flood resilience groups and hubs, and the assignment of volunteer flood wardens and community champions. Similar community-level initiatives could be adapted and scaled to bring localized risks to the forefront, incentivize the development of tailored solutions, and encourage communities to play their part in avoiding new risk generation. While local in nature, these initiatives can be integrated across different risks (such as droughts and heatwaves) or connected to other community topics (such as urban greening) to foster systemic results. This community-driven approach can increase the acceptability of policies and regulatory interventions, such as new zoning laws.

Innovative technologies linking early warning to early action

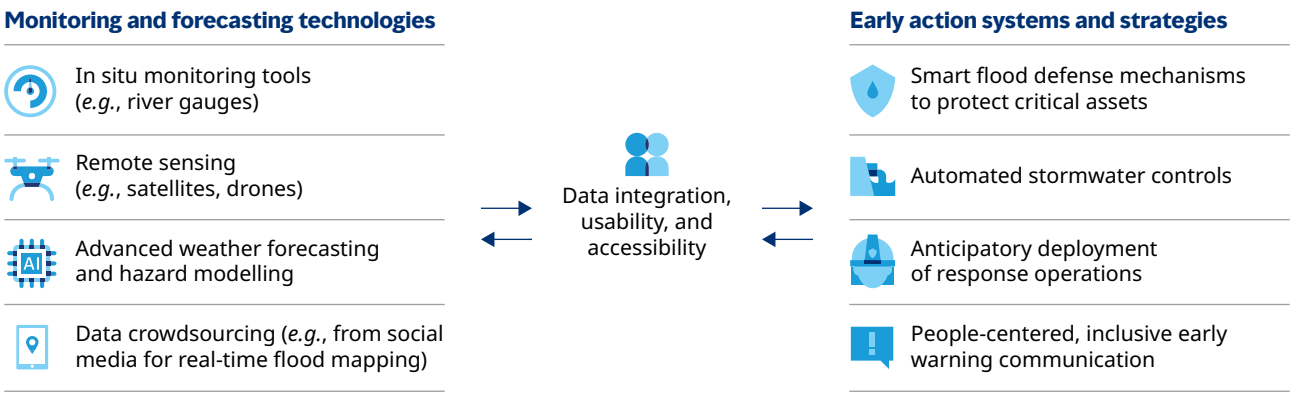
One component of living with floods effectively is creating strong emergency management systems that rely on anticipatory action rather than on post-disaster aid. New monitoring and forecasting technologies can be deployed to spur early action and prevent floods from turning into disasters (see Exhibit 8 on the next page).

Forecast-based financing (FbF) holds great potential in enabling proactive responses to floods. Pioneered by the International Federation of Red Cross and Red Crescent Societies, FbF solutions use weather forecasts and risk analyses to distribute humanitarian aid (such as food or medical supplies) before flooding hits, or to take preparative actions (for example, installing temporary flood barriers or managing water levels in dams).[54] FbF pilots are currently underway in Africa, the Americas and Asia-Pacific.[55] With advanced forecasting technologies to minimize false triggers, this approach could be scaled to mitigate flood impacts, particularly among vulnerable populations.

Another innovation utilizes weather forecasting for urban stormwater management.[56] A cloud-based smart watershed network management system, along with Internet of Things (IoT) technologies, is used to monitor and optimize water capacity ahead of floods. More than 170 projects have been deployed in the United States, and this technology has been effective in preventing flooding in cities during Hurricane Irma and Hurricane Dorian.[57]

Weather forecasts and satellites are also important for parametric insurance solutions such as the Excess Rainfall (XSR) model developed by the Caribbean Catastrophe Risk Insurance Facility. By estimating the probability of precipitation and related losses, XSR triggers payouts to countries shortly after the end of the event.[58]

Exhibit 8: Convergence of technologies to link early warning and early action (selected examples)



Source: Marsh McLennan

Insurance solutions incentivizing resilience interventions

When properly designed and implemented, insurance plays a vital role in catalyzing the adoption of resilience interventions. With integrated strategies that tie risk transfer to risk reduction measures, insurers can provide incentives to promote the deployment of resilience interventions.[59]

The purchase of policies can be accompanied by guidance for property-level protection measures. In April 2021, Flood Re in the United Kingdom, for example, launched the "Build Back Better" scheme to allow participating insurers to offer flood-hit customers additional funding, over and above losses and damage experienced, to install property-level protection measures. Insurers can claim the funds back from Flood Re.[60]

The Government of Canada recently established a Task Force on Flood Insurance and Relocation involving representatives from the central government, provincial and territorial governments, the insurance industry, and other stakeholders. It has assessed models for a national flood insurance program and identified incentivizing risk reduction and relocation measures as a priority to make coverage affordable.[61]

Other ongoing initiatives, such as the Business of Resilience, an industry-led taskforce in the United Kingdom, analyze cross-sector solutions to tackle the protection gap and build resilience.[62] The taskforce is working on proposals to integrate expertise in infrastructure resilience with tailored insurance and finance products to mitigate risks and provide access to otherwise unaffordable insurance

solutions. A similar initiative in the United States, Resilience Incentivization Roadmap 2.0, launched by the Committee on Finance, Insurance and Real Estate (CFIRE) and sponsored by Fannie Mae, brings together banking, insurance, and real estate leaders to develop a roadmap on mitigation investment.[63] This initiative aims to align incentives across stakeholders to facilitate the construction and retrofit of resilient buildings and infrastructure.

Global campaigns such as the UN Race to Resilience showcase examples of how insurance can de-risk, finance, and advance pre-event risk reduction efforts.[64] One of these examples is community-based catastrophe insurance (CBCI), demonstrating how new flood insurance solutions can be designed to create risk-reduction incentives at community level.[65] A CBCI program can create financial incentives by providing premium discounts based on resilience interventions and supports risk reduction strategies through the provision of risk analytics.[66] This can be applied at different scales, as demonstrated by a CBCI program in New York City, a partnership between the New York City Mayor's Office of Resilience, the Wharton Risk Center, Guy Carpenter, and other organizations. The program aims to expand coverage to lower- to middle-income households in New York City through parametric solutions while reducing risk levels through resilience investments.[67]

Another innovation is long-term risk transfer policies that break with the common 12-month policy renewal cycle. Climate Insurance-Linked Resilient Infrastructure Financing (CILRIF) leverages an innovative model to link insurance access to long-term resilience measures by delivering long-term (10-20 year) climate insurance to cities with pre-arranged premiums that depend on implementing city-level resilience measures. Initial pilots of CILRIF are underway in Makati (Philippines) and Durban (South Africa).[68]

Second way forward: Building strategic protection

Securing financial and physical resilience during more destructive floods is needed to complement local-level resilience efforts. Protection must be multi-layered and proactive, unlock early-action benefits, and leverage nature-based solutions for mitigating risks. These interventions must be financed via mechanisms that recognize co-benefits and by insurance solutions that incentivize risk reduction and resilience.

Small-scale resilience building is crucial but not sufficient to prepare for climate change and its interplay with other risk drivers. A society that has learned to live with floods still requires protection against destructive, tail risk events, particularly for essential assets and for locations where moving is not an option. This requires thorough and forward-looking strategic planning.

Existing approaches to physical and financial protection are insufficient, and bold transformations to business models, financial mechanisms, and regulatory approaches are required. Policy and regulatory shifts driving resilience investments have often followed in the wake of flooding catastrophes. To move beyond this reactive approach, it is crucial to demonstrate tangible returns on resilience. Quantifying co-benefits strengthens the case for investment and reduces uncertainties about returns. Scaling capital flows into resilience, however, requires that estimated protection dividends be incorporated into all co-benefit valuations.

Vision: Blending systemic physical and financial resilience

Society has realized that growing exposures and accelerating climate change mean protection cannot be achieved only via traditional engineered and risk transfer solutions. Instead, large-scale physical and financial protection measures are well integrated with low-level interventions and function as a backstop. A culture of risk management has enabled society to minimize maladaptation and lock-ins by moving beyond an overreliance on gray protection infrastructure and instead adopting sustainable approaches to protect people and assets. Water becomes a design driver for urban development, with new construction projects shaped by innovative and water-sensitive architectural solutions — such as leisure spaces that double as retention ponds. Floating settlements have become the norm rather than the exception in particularly exposed areas.

Society has embraced the potential of nature to protect against flooding. Better data analytics is critical in quantifying the value and effectiveness of nature-based solutions and facilitating the flow of public and private capital into sustainable interventions. Robust measurements of co-benefits lead to increased investments in preserving ecosystems to act as buffers against flooding. Nature-based risk management, which utilizes meadows, wetlands, and rivers to slow down and store water, becomes a core element of flood protection infrastructure.

These measures are complemented by investments in gray defense infrastructure to ensure additional protection for key areas. Resilience-focused cost-benefit analyses are carried out to determine the viability of such investments, including the ongoing costs of maintenance, repairs, and upgrades. This ensures that the response to changing risk levels can be planned in a timely fashion. While it is impossible to develop entirely fail-proof flood protection systems, these can ensure safety in the event of failure.

Growing exposures and accelerating climate change mean protection cannot be achieved only via traditional engineered and risk transfer solutions.

New forms of public-private collaboration pave the way for market solutions and blended interventions. Extensive collaborations between the public sector, financial institutions, infrastructure service providers, engineering firms, the construction industry, academia, and non-governmental organizations shape interventions and resilience efforts.

Underpinning these long-term efforts is a strong economic case for investing in resilience. Innovative financial mechanisms monetize resilience for investors, providing attractive returns. Standardized frameworks help investors measure resilience at

the asset, community, and country levels. Resilience assessments from rating agencies steer private-sector investments and shape risk-aware behaviors. By taking a forward-looking view on risk and rewarding investments in resilience, rating agencies create a virtuous cycle in which investors pursue returns from investments in resilience rather than abandoning high-risk areas. Governments and businesses report on their efforts to reduce risks and raise resilience across assets and supply chains, allowing investors to consider not only risk but resilience levels.

Risk finance is combined with risk reduction and adaptation efforts to secure affordable risk transfer solutions. New pools for communities and cities provide insurance and resilience finance. Investments in data and technology help to identify gaps in resilience, with schemes such as resilience bonds allowing those at risk to access capital to invest in adaptation and backstop risk transfer solutions.

Supported by governments and regulators, these initiatives create the conditions for a functioning private insurance market. The focus on risk reduction combined with insurance models such as parametric solutions and new capital frameworks for insurance companies improves their financial resilience, making it possible to extend coverage through a range of solutions such as resilience-focused public-private risk pools.

From vision to reality: Examples of innovative strategies

Enhancing systemic urban protection by designing water-sensitive urban infrastructure

Safeguarding infrastructure calls for integrating water-smart design into urban areas. Examples from different parts of the world show how infrastructure planning can be adapted to mitigate and prepare for flood risks. In Amsterdam, there's growing interest in floating housing structures, with architectural firms specializing in their constructions.[69] In Kuala Lumpur, a dual-purpose tunnel for traffic and stormwater management illustrates how infrastructure can be modified in a multi-functional manner.[70] In New York, a cloudburst management strategy is being developed to tackle flash flooding. The plan focuses on infrastructure installations to absorb, capture, or divert rainfall.[71] Public spaces like parks are being reimagined as multi-functional areas that can both serve as recreational areas and help absorb excess water. Similarly, basketball courts will be reconstructed using porous material at a lower elevation to trap water.[72]

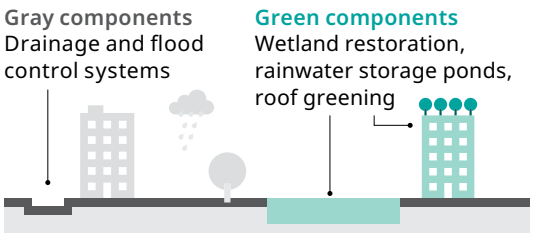
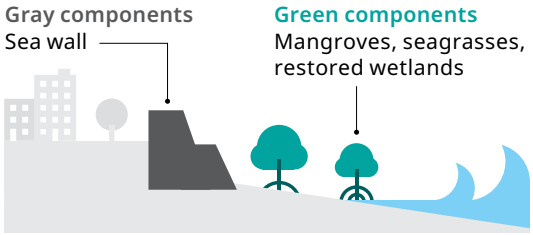
Adapting gray defense infrastructure to a changing climate

To build multi-layered protection, flood defense infrastructure must be designed to cope with changing risk levels from different climate hazards such as droughts, windstorms, erosion, and subsidence, and account for how they interlink. Implementing adaptation pathways for defense infrastructure enables early interventions. This is especially crucial considering the long lead time for large-scale projects and the lag between a triggering event (typically a devastating flood) that initiates the project and the eventual opening of the project, which can span several decades. The Thames Barrier in the United Kingdom, one of the largest retractable flood barriers in the world, serves as a model for forward-looking gray defense infrastructure. It helps protect 1.4 million people and £321 billion worth of property and infrastructure in London.[73] With an estimated protection lifespan until 2070, early preparation for the Thames Estuary 2100 plan is underway.[74] The first adaptive flood risk management strategy in the United Kingdom, the plan maps climate adaptation pathways, identifies solutions beyond 2070, and signals when upgrades or new investments are needed. This type of forward-looking planning strategy is critical to preparing for climate scenarios and should become the norm when investing in gray defense infrastructure.

Integrating gray and green infrastructure for enhanced protection

Pairing green measures with gray ones can generate more benefits than either strategy alone, including increased durability, lower costs, and enhanced levels of protection for both urban and rural areas. A study by The Nature Conservancy on flood mitigation along the Mississippi River found that levee setbacks with a nature-based approach offered superior flood protection (160-200 years) compared to traditional levees (50 years).[75] Levee setbacks enabled the creation of floodplain habitats, generating co-benefits such as improved water quality and species conservation, while the borrow pits of the new levees were converted into wetlands. Additionally, the nature-based levee setback model reduced insurance premiums for homes that were within five miles of the river. The value of green-gray solutions is gaining recognition across geographies (see Exhibit 9).

Exhibit 9: Case studies of integrating gray and green infrastructure

	How gray and green components work together	Co-benefits offered
Xiamen, Fujian, China: Sponge city infrastructure to retain and reuse stormwater 	• Natural systems can absorb and slow rainwater, relieving discharge pressure of stormwater on drainage systems • Cost-efficient because there is reduced maintenance and operation cost of pipelines	• Stormwater recycling • Added real estate value • Heat mitigation • Air pollution control • Recreational green spaces • Enhanced aesthetic value
Miami Beach, Florida, United States: Brittany Bay Park living shoreline to protect against coastal flooding and erosion 	• Green components act as natural barriers that attenuate wave action, reducing pressure on seawalls and extending their longevity • Cost-efficient as living seawalls grow stronger over time, as opposed to concrete seawalls that require regular repair and maintenance	• Water purification • Habitat for marine life • Carbon sequestration • Recreational green spaces • Enhanced aesthetic value

Sources: Conservation International, Miami Beach City Government

An evidence-based approach to nature-based risk management has been the basis for flood resilience initiatives, such as the Science for Nature and People Partnership (SNAPP).[76] SNAPP assembled a team of engineers, ecologists, and economists alongside insurance industry leaders to put a dollar value on the risk reduction provided by coastal wetlands. The partnership estimated that coastal wetlands prevented more than $625 million in property damage along the northeast coast of the United States during Hurricane Sandy, reducing property damage by 10% on average.

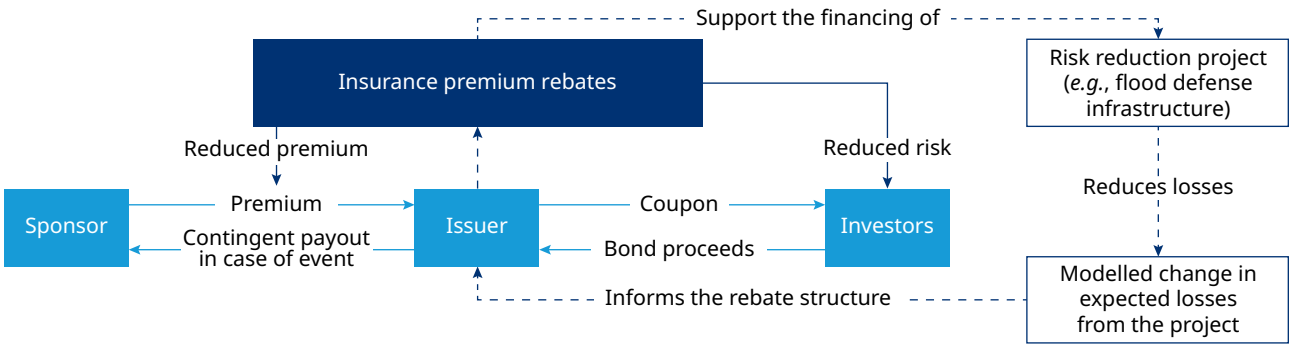
Monetizing resilience through a new generation of financing instruments

Climate finance tools such as green bonds create new funding opportunities for resilience projects, but they do not explicitly capture the value of future benefits generated by the projects. Innovative financial instruments that monetize resilience can make these benefits tangible, bringing future monetary gains forward to support project financing. Pilots of such innovative financial instruments are already underway. In 2016, the District of Columbia Water and Sewer Authority (DC Water) released the world's first Environmental Impact Bond, a 30-year municipal bond issued for $25 million, to fund green stormwater infrastructure.[77] The bond employs a pay-for-success approach that provides upfront capital to governments for resilience programs, and private investors are compensated based on measured outcomes. If the new green stormwater infrastructure exceeds performance expectations (that is, stormwater runoff reductions are greater than a predetermined threshold), investors are rewarded with a one-time additional outcome payment of $3.3 million, and vice versa, if it underperforms. If the performance is as expected, the EIB functions as a normal municipal bond with investors receiving the stated interest rate.

A five-year pilot of this project showed positive results with 20% stormwater runoff that met performance expectations, yielding social, environmental, and financial benefits to DC Water, investors, and the public. Similar models for financing green infrastructure can be replicated and expanded in other regions.

Resilience bonds are another innovative financing solution for monetizing resilience. These are a hybrid of green and catastrophe bonds that bridge the gap between physical and financial resilience by combining insurance protection with risk reduction. Catastrophe models, which compare expected losses with and without the project, quantify the risk reduction value generated by the resilience project. This difference is then captured as a premium rebate. In this manner, funds for financing the project can be brought forward.[78] The insurance component of the resilience bond functions like a regular catastrophe bond, with rapid payouts made to the sponsor, when a pre-defined catastrophe threshold is hit (see Exhibit 10). Defense infrastructure projects such as flood barriers make them suitable options for resilience bonds. However, despite their promise, these financial products struggle to gain traction due to a lack of regulatory frameworks and the complexities involved in modelling risk reduction.

Exhibit 10: Simplified conceptual structure of a resilience bond



Source: École Polytechnique Fédérale de Lausanne

New regulatory and disclosure requirements spurring innovations in risk transfer

Governments are often considered insurers of last resort and are expected to step in to cover losses and fund recovery efforts. However, given the catastrophic and frequent nature of flooding, this approach is unsustainable. Guaranteeing the financial sustainability of insurance requires new mechanisms to transfer risks to capital markets.

Alternative capital sources from pension funds, hedge funds, and endowments have incentivized the development of innovative risk transfer solutions such as catastrophe bonds, resulting in greater coverage at lower costs.[79] This approach could be expanded to new resilience-focused insurance mechanisms such as resilience pools. However, deployment of transformative risk transfer solutions is still at an early stage. Mutual risk pools that embed measures for preparedness and risk reduction as a condition of cover are being tested in emerging markets. The African Risk Capacity, which combines drought risk insurance with contingency planning services, improved risk forecasting systems, and access to international funding, was designed with this objective in mind.[80]

Early efforts to develop resilience-focused risk transfer products have faced a range of challenges, and there is no widespread application of these solutions. New regulatory frameworks and increased disclosure requirements could spur innovation. Capital adequacy frameworks could be updated to account for climate change, such as in the case of Solvency II.[81] Capital adequacy parameters may also be linked to investments in flood mitigation and adaptation, freeing up capital to be invested in risk reduction projects linked to risk transfer solutions.

Disclosure requirements can be updated to account for climate change impacts, ensuring that insurers are prepared to withstand the challenges posed by rising risk. The Bank of England's Prudential Regulation Authority embeds climate change impacts — including trends in flood risk — in its approach and requires insurers to stress test their portfolios.[82] This can lead to innovations in risk transfer solutions by improving risk assessment, promoting data sharing, and helping insurers and policyholders make informed and forward-looking decisions. Demonstrating the alignment of risk transfer and risk reduction is technically challenging but feasible and can help fuel the shift to a new generation of financial protection schemes.

Third way forward: Preparing for relocation

In high-risk locations, it may not be feasible to implement measures to accommodate floods or build protection. Planned relocations of people and assets can be both economically efficient and equitable, but making resettlements sustainable calls for new financial and socioeconomic incentives.

There are financial and technical limits, however, to the first two ways forward. This is already a reality in some coastal areas and small island nations. Often considered ”a last resort“, once all other measures have failed, the planned relocation of people and assets from highly vulnerable areas will become increasingly necessary, and, in many cases, be the only solution. Relocations involve a complex web of stakeholders with varying priorities and cultural backgrounds. This makes relocation politically charged and socially disruptive. Decisions about who should be relocated, when and where, and how to finance operations must be addressed in a way that ensures the interests of stakeholders are taken into account. Moving people and assets out of harm’s way can take many forms and be sequenced over different timeframes. Planning and setting guiding policies and financial mechanisms for when relocations need to happen is a crucial aspect of flood risk management. Failing to plan relocation strategies could result in catastrophic outcomes. The latest Intergovernmental Panel for Climate Change report projects that millions of people will face displacement and involuntary migration by the end of the century, compromising human security, economic and political stability.[83]

Vision: Making relocations socially and financially sustainable

Planned relocations are recognized as an effective adaptation response. Risk assessments serve as the basis for action, and countries lay the foundations for relocations early with anticipatory governance structures and long-term funding arragements. Frameworks and regulations to govern the process (see Exhibit 11 on the next page), incorporating lessons learned from past experiences, are in place. Relocations happen at the right pace and are triggered in a timely manner by changing risk levels, with slow-impact changes prompting more gradual action.

Governments work with communities, businesses, and non-governmental organizations to develop a shared vision on how and when relocations should happen. Resettlements are not simply framed as a real estate problem, only engaging those stakeholders involved in purchasing properties and governing land use. Instead, they are seen as a societal challenge, requiring input and buy-in from a broad range of stakeholders. Their participation brings discussions on the consequences and benefits of relocations to the forefront of resilience planning. Communities are empowered to contribute to decisions on acceptable levels of risk and can identify priorities, such as the preservation of cultural heritage.

Long-term national adaptation plans show how relocations can be helped by strategic investments in resilience efforts and protection. Relocation processes are well integrated with other policy frameworks and coordinated with protective infrastructure decisions. Policies are fair and transparent, addressing the issues of compensation and consent through rigorous accountability mechanisms. The prospect of relocation is also triggering innovations across the first two ways forward. For example, designs such as floating settlements in coastal communities allow residents to remain close to their old homes.

Mechanisms to redirect resources from disaster relief to pre-emptive buyouts enable societies to avoid a pattern of cyclical destruction and rebuilding. Areas that are abandoned are used to build resilience through nature-based solutions or land use interventions, such as turning streets into interconnected canal networks. In countries with space constraints, such as small island states, relocations take place across borders and are governed by international agreements.

New financing and funding mechanisms based on long-term cost minimization and distributional fairness are deployed at scale and in a context-specific manner, providing security to affected residents.[84] Planned relocations enable disadvantaged residents to

break the flood cycle, especially those who cannot afford to sell their homes at a loss and are forced to reside in flood-prone areas. The implementation of timely and diversified financing measures allows societies to leverage several options to facilitate relocations at significantly lower future costs.

Planned relocations can achieve societal transformation by tying them to wider objectives such as economic growth, poverty alleviation, and public health. They help communities thrive in a changing climate, incorporate new innovations, address long-overlooked needs of residents, and reinvigorate local economies. Planned relocations now represent a sustainable, financially efficient, and equitable solution.

Exhibit 11: Selected relocation policies and examples from around the world

COUNTRY	POLICIES AND GOVERNANCE
Fiji	A national framework called Planned Relocation Guidelines was launched in 2018 to standardize procedures for relocations
Indonesia	Parliament passed a bill in 2022 to move the country's capital from Jakarta to Nusantara (Kalimantan)
New Zealand	Legislation will be introduced in 2023 to address legal, funding, technical, and governance challenges associated with managed retreat
United Kingdom	The 2010 policy supplement on Development and Coastal Change promotes planned relocations and rollback of development, infrastructure, and habitat to more sustainable locations further inland
United States	The Disaster Recovery Reform Act of 2018 has incorporated relocation into the country's hazard mitigation strategy. Relocations are typically undertaken through property buyouts financed by both federal and state funding
Vietnam	The Living with Floods program was established in the late 1990s and has relocated more than 1 million households

Sources: Government of the Republic of Fiji, Government of New Zealand, Cabinet Secretariat of the Republic of Indonesia, United Kingdom Government, United States' Federal Emergency Management Agency, Environmental Change and Agricultural Sustainability in the Mekong Delta

From vision to reality: Examples of innovative strategies

Breaking the rebuilding cycle and enforcing forms of limited property ownership

Orchestrating large-scale relocations in response to slow-onset climate events requires investment and adequate lead time to implement. To overcome these barriers, a phased approach is taken to relocations, with interim measures to spur disinvestment from certain areas or limit property ownership. Legislators can impose tighter restrictions on rebuilding to encourage residents to relocate away from flood-prone areas. In the United States, laws introduced in Maine and South Carolina prescribe that if a structure is damaged by more than 50% of its appraised value during a storm, it cannot be rebuilt.[85] Other regulatory interventions, such as life-estates and leaseback schemes, have been utilized by the government to purchase properties in high-risk areas. In a life-estate scheme, residents' ownership of their homes terminates when they die. The Florida Forever program has acquired over 869,000 acres through life-estates which are maintained for agricultural or conservation purposes.[86] These schemes offer a flexible approach to manage relocations, allowing property owners to reside in their homes during their lifetimes while reducing future exposure to risk.

Balancing local-level relocations with tighter resilience requirements

In some areas, relocations can be integrated with development planning by aligning incentives based on risk levels. For instance, the approach taken by the coastal city of Norfolk, Virginia, demonstrates how linking planning permissions to resilience requirements can encourage property developers to relocate to a lower-risk area within the city.

The Norfolk city government worked with local developers, builders, and non-profits to develop an innovative zoning approach to adapt to short-term and long-term flood risks. They implemented two zoning overlays and a point-based resilience quotient for all new buildings to secure permits. The Upland Resilience Overlay (URO) covers lower-risk, elevated areas and has a lower resilience quotient requirement, whereas the Coastal Resilience Overlay (CRO) encompasses zones in the floodplain and is subject to more stringent resilience quotient provisions. Property developers who relinquish development rights in the high-risk CRO receive resilience points that can be utilized in the safer Upland Resilience Overlay. This approach allows property developers to choose between making additional investments in resilience to stay in high-risk areas or relocating to safer areas.[87]

Developing innovative financial solutions for relocation

As conventional approaches become unsustainable, new financial solutions will be needed to fund relocations on a growing scale. Relocating just 10% of the most vulnerable homeowners in the United States with post-hoc buyouts, for example, is estimated to cost nearly $500 billion.[88] Moreover, for slow-onset events such as coastal erosion and coastal flood inundation caused by sea level rise, most countries lack financing or funding mechanisms to incentivize residents to relocate from high-risk areas.

To respond to these challenges, the United Kingdom's Department for Environment, Food and Rural Affairs and Coastal Partnership East commissioned the Coastal Loss Innovation Funding and Financing (CLIFF) study.[89] The analysis reviewed various schemes targeted at residential properties in England and Wales that are at risk of coastal erosion and shortlisted three solutions (see Exhibit 12). While this study focuses on England and Wales, the principles and models adopted can be adapted to other regions facing similar challenges.

Exhibit 12: Three financing options reviewed by CLIFF to relocate properties at risk of coastal erosion

	COASTAL ACCUMULATOR FUND	LEVY MODEL	LOCAL AUTHORITY COASTAL ADAPTATION FUND
How it works	Homeowners contribute to a fund tied to their property	Levy raised via mechanisms such as household insurance, either nationally, regionally, or in at-risk coastal areas	Local authorities pool funds from properties at risk
Advantages	Build-up of property fund over time could balance any depreciation in property value	Levy can be administered via existing mechanisms such as Flood Re, offering scope for greater participation	Funds can support properties that are more immediately at risk
Disadvantages	May require the implementation of mandatory contributions to draw enough homeowners	Administering a nationwide levy and obtaining buy-in from insurers can be challenging	May need seed investments for the fund to be sustainable

Source: Marsh

Promoting social welfare through equitable relocations

Situating planned relocations within wider resilience objectives can ensure that they are equitable and enhance the adaptive capacity of communities to deal with future crises. A community-driven relocation scheme for residents living in informal settlements along flood-prone areas of the degraded Caño Martín Peña channel in Puerto Rico is an example of how relocations can unlock ecological, social, and economic benefits.[90]

The relocation was part of a comprehensive land use and development strategy to address issues of flooding, water contamination, and pollution in the Caño Martín Peña district. It involved 700 participatory activities in two years to bring together residents, non-profits representing local communities, and government agencies to organize an equitable relocation plan. At its heart was the establishment of a Community Land Trust, an innovative model of formal land ownership that gave residents rights over their land and ensured that the relocation was voluntary. Six hundred households were resettled collectively, and 1,300 more households are currently undergoing the process. The relocation also created space for green infrastructure, improved sanitation, and fostered a sense of community responsibility. Similar models can be implemented to safeguard the rights of residents exposed to flood risk and promote social and economic development.

Mobilizing action

Scaling and funding transformative efforts requires bold action. Overcoming current inefficiencies is a tall order and involves tearing up old approaches and reconsidering roles and responsibilities. A clear vision, stakeholder engagement, education, and incentivization can pave the way forward. To break the disaster cycle, critical enablers across governance and risk culture, land use and infrastructure planning, and finance and insurance are needed.

Transforming flood risk management requires putting risk knowledge and resilience solutions to use in an anticipatory and integrated way. The examples of innovative strategies presented in Chapters 4-6 offer a glimpse of how this can play out along the three ways forward. The complexity of the challenge means that a combination of strategies is needed, along with capable leadership and stakeholder collaboration. There is a narrowing window of opportunity to drive transformative change. Therefore, the three ways forward need to be considered concurrently and should comprise a portfolio of synergistic strategies.

Not everyone can be protected, insured, or bailed out. To enable the transformation, decision-makers within government, regulatory bodies, businesses, and communities must be prepared to confront difficult trade-offs. An immediate priority is to set clear rules and responsibilities that are underpinned by knowledge of risk and do not shield stakeholders from the consequences of their risky decisions. Taking different types of stakeholders on the journey is crucial. To achieve this goal, strong narratives about co-benefits and clear information on risk levels and resilience strategies are essential.

Mobilizing the transformation requires immediate action, including the following steps.

Build a risk culture that balances fairness and individual responsibility by

- **Replacing protection goals with resilience objectives.** In the past, objectives were formulated around protection levels — an approach that is no longer tenable. Instead, clear resilience objectives at the community, regional, national, and cross-sectoral levels are essential to accelerate action in flood risk management, including the delivery of the resilience outcomes described for 2030 by the Sharm-El-Sheikh Adaptation Agenda.[91] When necessary, these objectives should be underpinned by international standards, sector-specific codes of practice, and flood certificates for homes and other assets.
- **Integrating resilience and forward-looking considerations into existing risk models.** The rollout of next-generation flood risk models that incorporate information on changing risk levels and the effectiveness of different resilience measures is essential for the transformation of flood risk management. The models must also account for the interdependencies between flooding and other risk drivers, such as nature loss.
- **Informing not only about risk trends, but also about the effectiveness of risk management practices and the choices of resilience measures.** Accessible information on changing risk levels and the efficacy of resilience measures is crucial. Building a risk culture centered on transparency allows discussions on relocations to be brought to the forefront of flood risk management.

Transform land use and infrastructure planning by

- **Switching to innovative mechanisms to govern land use and infrastructure.** This requires resilience-focused regulations and adaptative design approaches that incorporate information on changing risk levels. Greater policy coordination to strengthen land use planning and flood zoning will help to avoid lock-ins and enable early planning for relocation.
- **Ensuring the enforcement of building standards.** Multiple means are available, such as monitoring technologies, penalties for non-compliance, and holding developers and builders accountable for future risks. This can be paired with rewards and tax incentives for exceeding resilience standards.
- **Establishing statutory requirements for the combination of green and gray infrastructure.** Recognizing the role that nature plays in addressing flood risk is critical. Joint strategies that bring together different regulators, such as water authorities and flood management agencies, can be powerful enablers.
- **Offering financial incentives for rural land management.** Payments for the alleviation of flooding and other instruments such as land sales, leasebacks, easements, and annual payments to mobilize the provision of flood resilience services by land managers can be strong incentives.

Mobilize financial capital for flood resilience by

- **Standardizing co-benefit assessments and integrating them into ESG frameworks.** Clarity on flood risk management co-benefit metrics and on the methodologies used for their quantification can help monetize resilience. ESG-focused investing and integrating flood resilience into green finance taxonomies can transform risk management practices and mobilize capital for flood resilience.
- **Strengthening the role of resilience ratings in awarding public and private contracts.** Public funding and private sector procurement tied to resilience efforts can incentivize investment in resilience. Flood resilience measures can be integrated into TCFD disclosures and other reporting frameworks.

Shift to a resilience-focused insurance system by

- **Removing regulatory barriers.** Innovations can be served by changing regulatory frameworks to enable resilience incentives in the underwriting process.
- **Creating innovative insurance models.** Flood risk management and adaptation can be integrated into the design of risk transfer products, such as innovative pool solutions, long-term insurance arrangements tied to an asset or through the rollout of resilient reinstatements and repairs as part of the claims process.

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