RISING TO THE CHALLENGE

Success Stories and Strategies for Achieving Climate Adaptation and Resilience

WORLD BANK GROUP
Climate Change

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Cover photo: Farmer in rice field in Cianjur District, West Java, Indonesia. Credit: ©rudi_suardi/istock.com
Design and layout: Fiorella Gil, ULTRA Designs, Inc.

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Acknowledgments

The preparation of this report was led by Jia Li, Esther Naikal, and Thomas Kerr under the overall guidance of Stéphane Hallegatte. The core team comprises Jia Jun Lee, Francisna Fernando, Chloé Desjonqueres, Nisan Gorgulu, Camilla Knudsen, Penny Mealy, Ammara Shariq, and Jichong Wu.

The case studies were prepared by teams from the World Bank and the International Finance Corporation (IFC), including: Paolo Avner, Anam Basnet, Sarah Coll-Black, Jana el-Horr, Habiba Gitay, Mohammad Rafiqul Islam, Bramka Jafino, Melanie Kappes, Camilla Knudsen, Jia Jun Lee, Nancy Lozano Gracia, Olivier Mahul, Sean Michaels, Tevi Obed, Ashley Pople, Anja Robakowski, Evelyn Sanchez Hernandez, Jun Rentschler, Varun Shankar, Tatiana Skalon, Vladimir Stenek, and Sara Turner. David Carlin of UNEP FI, Anne Chataigne and Mahesh Roy of IIGCC, Lori Collins of GARI Group, Marie Diron and Swami Venkataraman of Moody's Ratings, Caitlin Drake and Felicity Spoors of Gold Standard, Irene Heemskirk of the European Central Bank, Jane Jamieson of PPIAF, Alexander Kennedy of Standard Chartered Bank, Ariane Pevide and and Michael Keane of Mitsubishi UFJ Financial Group, Ujala Qadir of Climate Bonds Initiative, and Nicola Ranger of the University of Oxford contributed input and review of private sector and related case studies. Neven Fučkar of the University of Oxford provided input on climate risk and vulnerability contexts.

The country adaptation and resilience readiness assessments were prepared by many colleagues across the World Bank Group, some as part of the Country Climate and Development Report process. The team is grateful for support and methodological and data input from Julie Rozenberg, Thomas Farole, Stavros Papageorgiou, Ellysar Baroudy, Ahmed Al Qabany, Craig Meisner, David Groves, Giovanni Ruta, Kai Kaiser, Elena Golub, Paola Agostini, Juan Jose Miranda Montero, Tao Wang, Katherine Stapleton, Andrea Liverani, Julian Lee, Sophie de Vries Robbé, Natalie Weigum, Serge Mandiefe Piabuo, Melanie Kappes, Ashley Pople, Yurani Arias Granada, Diji Chandrasekharan Behr, Raffaello Cervigni, Rangeet Ghosh, Wanli Fang, Philippe Ambrosi, Jun Rentschler, Phearanich Hing, and Zoran Kapor.

The team gratefully acknowledges the invaluable comments and advice provided by peer reviewers: Chiara Bronchi, Kevin Carey, Jana el-Horr, Nathan Engle, Forhad Shilpi and Vladimir Stenek. We are also thankful for comments and insights received from: Seth Ayers, Doerte Doemeland, Verena Fritz, Elisabeth Huybens, Sebastian Molineus, Franziska Ohnsorge, Julie Rozenberg, Sandhya Srinivasan, Asmita Tiwari, and Wei Zhang.

The report would not have been possible without the communications, editorial, and publishing teams. Ferzina Banaji led the communications strategy and engagement with support from Lucy Buckley and Joana Lopes. Pascal Saura also provided invaluable support. The report was skillfully edited by Lucy Southwood and designed by Fiorella Gil (ULTRA Designs).

This work was conducted with guidance from Renaud Seligmann (Director for Strategy and Operations of the Planet Vice Presidency), Jennifer Sara (Director of the Climate Change Group), and Hania Dawood (Practice Manager of Climate Finance and Economics in the Climate Change Group), and under the overall direction and leadership of Juergen Voegele (Vice President of the Planet Vice Presidency).

Acronyms

A&R	adaptation and resilience
AGIR	Guinean approach for identification of risks
AI	artificial intelligence
AMC	Ahmedabad Municipal Corporation (India)
ANAFIC	National Agency for Local Government Financing (Guinea)
ASA	Articulação Semiárido Brasileiro (Brazil)
BAMIS	Bangladesh Agrometeorological Information System
BMD	Bangladesh Meteorological Department
BWDB	Bangladesh Water Development Board
Cat DDO	Catastrophe Deferred Drawdown Option
CAVA	climate adaptation vulnerability assessment
CCDR	Country Climate and Development Report
CCRIF-SPC	Caribbean Catastrophic Risk Insurance Facility
CRAFT	Climate Resilient Agribusiness for Tomorrow (project)
CRISP	Climate Resilience Investments in Solutions Principles
CTIP3	climate toolkits for infrastructure PPPs
DAE	Department of Agricultural Extension (Bangladesh)
DRF	disaster risk finance
DRFI	disaster risk finance and insurance
DRM	disaster risk management
EbA	ecosystem-based adaptation
ECB	European Central Bank
EDC	Energy Development Corporation
EU	European Union
EWS	early warning system
FNDL	National Fund for Local Development (Guinea)
FODEL	Local Economic Development Fund (Guinea)
FSEC	Solidarity Fund against Catastrophic Events (Morocco)
FWC	First Water Cisterns (program)
GDP	gross domestic product
GGA	Global Goal on Adaptation
GHG	greenhouse gas
GMD	Global Monitoring Database
HAP	heat action plan
HIC	high-income country
hydromet	hydrometeorological
IFC	International Finance Corporation
LDRRMF	local disaster risk reduction and management fund (Philippines)
LIC	low-income country
LLA	locally led adaptation

LLCA Locally Led Climate Action
LMIC lower-middle-income country
LoCAL Local Climate Adaptive Living Facility
MEbA Microfinance for Ecosystem-based Adaptation (project)
MEL monitoring, evaluation, and learning
MHEWS multi-hazard early warning systems
MIC middle-income country
MoCCA Ministry of Climate Change Adaptation, Meteorology, Geo-Hazards, Energy, Environment and Disaster Management (Vanuatu)
MRV monitoring, reporting and verification
MW megawatts
NAP National Adaptation Plan
NARS National Asset Registry System (Philippines)
NbS nature-based solutions
NDC nationally determined contribution
NGO nongovernmental organization
NIIP National Indemnity Insurance Program (Philippines)
O&M operations and maintenance
P1MC One Million Cisterns Program (Brazil)
PAGL Guinea Support to Local Governance Project
PBC performance-based condition
PCRAM Physical Climate Risk Assessment Methodology
PCRTP Pacific Climate Resilient Transport Program
PG&E Pacific Gas and Electric Company (United States)
PIC Pacific Island country
PPIAF Public-Private Infrastructure Advisory Facility
PPP public-private partnership
PV photovoltaic
RiST (Climate) Risk Stress Test
RRS Resilience Rating System
SAFER Bay Strategy to Advance Flood Protection, Ecosystems, and Recreation along the San Francisco Bay (program)
SCE Southern California Edison (United States)
SIDS Small Island Developing States
SME small and medium-sized enterprise
SMS short message services
TCIP Turkish Catastrophe Insurance Pool
UAE United Arab Emirates
UMIC upper-middle-income country
UN United Nations

All dollar ($) amounts are US dollars.


FROZEN

Executive summary

PHOTO:
A girl returning from school wades across a flooded street after heavy rains, in Guwahati, India.
Credit: © D. Talukdar/istock.com

In Ahmedabad, India, the extreme heat warnings established as part of the first heat-health action plan in a South Asian city saved thousands of lives in its first two years of implementation. Vanuatu, a highly vulnerable Small Island Developing State, has embarked on a journey to reform its institutions and integrate climate adaptation and disaster risk management into development policies, land use plans, and infrastructure projects, ensuring that the country and its communities are better prepared for a future with accelerating climate impacts. At the same time, a commodity broker is helping to implement large-scale agroforestry programs in Côte d'Ivoire, aimed at restoring ecosystems, sequestering carbon, and improving soil fertility, while also supporting farmers' livelihoods. Private electricity utilities are increasingly including climate risks in their business decisions and investing in resilience, and the financial sector is developing new strategic partnerships and innovative fund structures to channel more capital into resilience solutions for vulnerable populations and regions.

In the context of increasingly visible climate change and disaster impacts, and the widely recognized need to do more to adapt and prevent them, these success stories of private actions, locally-driven solutions, and government interventions offer a vision of what can be done. As well as contributing to faster, better, and more resilient development, these actions are replicable with appropriate adjustments in other contexts, and can be scaled up to build resilient communities, businesses, and economies.

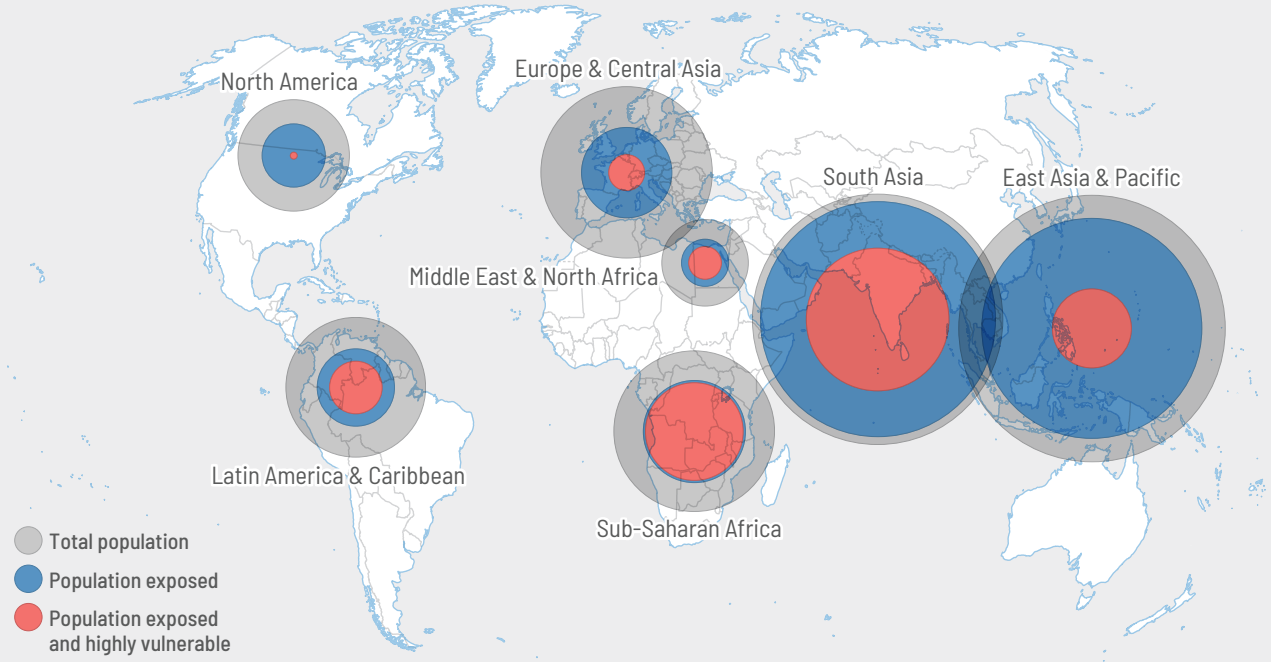
Building on what can be learnt from these initiatives, this report aims to frame the adaptation and resilience (A&R) imperative in the context of global development challenges, and to offer examples of successful and replicable actions that can accelerate progress toward more resilient development and poverty reduction.

Climate change and extreme events are increasing, as are their impacts

As the climate changes, countries, businesses, and communities must adapt. The earth's climate system is experiencing an unprecedented rate of warming that has already led to record-breaking heatwaves, droughts, storms, floods, and wildfires. There is evidence that climate impacts are undermining progress toward the Sustainable Development Goals (WMO 2023). Vulnerable countries, people, and communities are disproportionately affected. Warming has slowed down the convergence in income between countries in recent decades (Diffenbaugh and Burke 2019); and within countries, the expected impacts of climate change on the bottom 40 percent are, on average, 70 percent higher than those on the average population (Hallegatte and Rozenberg 2017). Children are particularly vulnerable to climate risks, with long-term impacts on economic and human capital development (UNICEF 2023).

About one-fifth of the world's population is at high risk from climate-related hazards. A new analysis to inform the World Bank scorecard overlays spatial data of key climate hazards (heatwaves, droughts, floods, and cyclones) with household data to count people who are both exposed and highly vulnerable due to their propensity to be adversely affected or their inability to cope with the impacts (Hill et al., forthcoming). Estimates from 103 countries, which comprise 86 percent of the global population, show that 1.2 billion people are both exposed to at least one climate-related hazard and highly vulnerable (figure ES.1). While high-income countries have large populations exposed to climate-related hazards, most

FIGURE ES.1. SHARE OF POPULATION THAT IS EXPOSED AND HIGHLY VULNERABLE BY REGION, 2021



Source: World Bank staff calculations using World Bank Group Scorecard indicator data on *percentage of people at high risk from climate-related hazards* (https://scorecard.worldbank.org/); Hill et al. (forthcoming)

people at high risk are in South Asia and Sub-Saharan Africa; this is a consequence of lower income levels and a lack of access to the basic infrastructure and social services people need to cope with and recover from shocks.

Development, adaptation, and resilience are inseparable

KEY MESSAGE #1

Reducing climate and disaster impacts on people, communities, and economies requires more rapid development, more resilient development, and targeted adaptation interventions. Only a whole-of-society strategy will allow countries to coordinate efforts across sectors and support people, the private sector, and communities to build resilience.

Rapid, inclusive development, poverty reduction, and access to basic services are crucial for enhancing adaptive capacity and the resilience of people and communities. There is a wealth of evidence demonstrating the interconnectedness of development progress and adaptation. Adaptation interventions alone cannot make people and households resilient; they also need to have access to basic infrastructure services (such as energy and improved water), financial instruments (such as saving accounts and borrowing), and critical services (such as health care).

Thanks to economic development, the share of people at high risk from climate-related hazards has halved within a decade. Increased gross domestic product (GDP) per capita is associated with lower impacts of climate change on GDP and poverty, lower well-being losses from natural hazards, and a lower share of population at high risk from climate-related hazards (table ES.1). Although GDP per capita does not influence asset losses due to climate-related hazards in a

TABLE ES.1. A 10 PERCENT INCREASE IN GDP PER CAPITA IS ASSOCIATED WITH IMPROVEMENTS IN VARIOUS RISK OR RESILIENCE METRICS

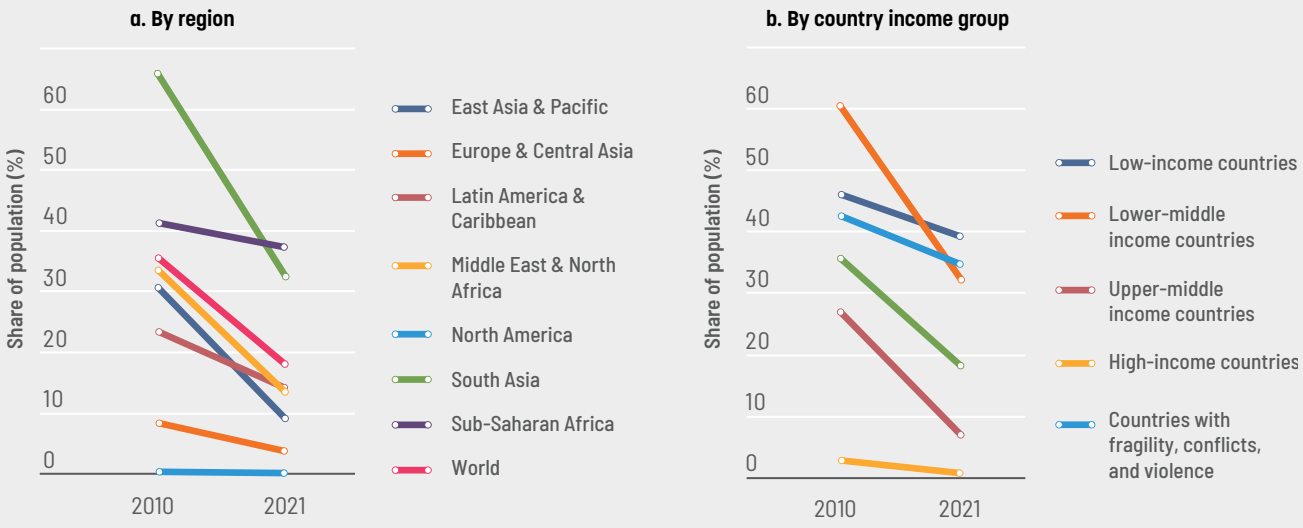
RISK OR RESILIENCE METRIC	CHANGE	BASED ON
Proportion of people highly vulnerable to climate-related hazards	2.8 percentage point reduction	http://scorecard.worldbank.org/; Hill et al. (forthcoming)
Proportion of people at high-risk from climate-related hazards	1.5 percentage point reduction	
Absolute asset losses (in $ per capita) from natural disasters	8.6 percent increase	CDRI (2023)
Relative asset losses (in % of GDP) from natural disasters	1.2 percent reduction (not significantly different from zero)	
Socioeconomic resilience from natural disasters	0.8 percentage point increase	Middelanis et al. (forthcoming)
Absolute well-being losses (in $ per capita) from natural disasters	7.4 percent increase	
Relative well-being losses (in % of GDP) from natural disasters	2.4 percent reduction	
Number of people falling in extreme poverty in 2030 due to climate change	5 percent reduction	Jafino et al. (2020)
Expected GDP losses due to (a subset of) climate change impacts in 2050	0.2 to 0.3 percentage point reduction	World Bank Group (2024)

statistically significant manner relative to total GDP and as estimated by CDRI (2023), it does influence macroeconomic impacts, well-being impacts, and extreme risk levels. A 10 percent increase in GDP per capita translates into a 0.2–0.3 percentage-point reduction in the estimated impact of climate change on GDP in 2050, a 5 percent decrease in the number of people living in poverty due to climate change in 2030, a 2.4 percent reduction in average well-being losses from natural disasters (as share of GDP), and a 1.5 percentage-point decline in share of population at high risk from climate hazards. It means that a 10 percent increase in income could reduce the global population at high risk by almost 100 million people. This benefit from economic development is also visible in the evolution of the number of people at high risk from climate-related hazards, which has halved within a decade, dropping from 36 to 18 percent of the global population between 2010 and 2021 (figure ES.2).

While increased development is a requisite for improved resilience, it is not sufficient on its own: countries also need to achieve better development through climate-informed policies. Income growth only explains a fraction of the differences in resilience and risk levels. This means that countries at all income levels can do more to boost resilience and reduce risks. Policy choices regarding inequality, financial inclusion, infrastructure development and quality, and social safety nets can enhance adaptive capacity and socioeconomic resilience at any income level. To deliver the expected development gains despite climate and disaster risks, development policies and investment decisions also need to be climate-informed. There is a growing number of examples of how better development can deliver higher resilience, including:

- **Ensuring that urban development takes place in safe areas:** With urban growth in the most hazardous flood zones outpacing growth in safe zones (Rentschler et al. 2023), driving rapidly urbanizing populations toward safer areas can prevent flood losses and protection or resettlement costs. This

FIGURE ES.2. SHARE OF POPULATION AT HIGH RISK FROM CLIMATE-RELATED HAZARDS, 2010–21



Source: World Bank staff calculations using World Bank Group Scorecard data on *percentage of people at high risk from climate-related hazards* (https://scorecard.worldbank.org/); Hill et al. (forthcoming)
Note: Countries are excluded if the underlying survey data are not within a three-year window around the reporting year.

is particularly so for informal settlements, which tend to be exposed to higher levels of risk.

- **Building infrastructure with resilience standards that consider current and future climate risks and incorporating nature-based solutions:** In low- and middle-income countries, more resilient power, water, sanitation, and transport sector assets would cost around 3 percent more, on average. But over their lifetimes, the net benefits could reach an estimated $4.2 trillion, or $4 for each $1 invested (Hallegatte, Rentschler and Rozenberg 2019).
- **Reallocating direct public investment and distortive public subsidies to ensure a more resilient development pathway:** Subsidies in the energy, water, agriculture, and land sectors total $1.2 trillion per year and often have a negative effect on resilience by incentivizing excessive risk-taking and degrading natural areas or ecosystem services (Damania et al. 2023).

But countries cannot manage climate change and natural hazards through faster and better development alone: retrofitting and targeted risk management and adaptation interventions will also play a key role in reducing future impacts. For example, countries will need to upgrade their river and coastal flood defenses in response to changing hydrology and sea level rise. On average, annual capital costs for river flood protection in low- and middle-income countries would need to be 0.04–0.47 percent of GDP, while maintaining the current absolute level of risk would cost 0.15—2.4 percent of GDP (Rozenberg and Fay 2019). And due to more frequent and intense heatwaves, countries will need specific interventions to retrofit buildings to make them healthier, more comfortable, and more energy efficient.

> **The balance between the three elements—faster development, better development, and targeted interventions—will depend on the context.** In high-income countries, where people have universal access to basic social, financial, and infrastructure services, the focus will naturally be toward targeted intervention to adapt existing systems and infrastructure to cope with increased climate impacts. In rapidly-growing low-income countries, where most of these systems still need to be built, the broader development agenda will play a much bigger role, and this will have implications for both financing and resources (box ES.1).

BOX ES.1.

Capturing the full picture of adaptation financing

Investment needs and financial flows for adaptation and development are impossible to separate, particularly in low-income countries. The broader framework proposed in this report suggests higher investment needs for resilience, because they include expenditures that are more often considered "development needs"—such as providing universal access to improved water, sanitation, or electricity—that are foundational for resilience (UNEP 2023; CPI 2023; World Bank Group 2023d, 2024). This contrasts with estimates of climate finance, which focus on investments with explicit adaptation needs or that involve incremental costs (CPI 2023). The limited scope of existing estimates partly explains why only 5 percent of total climate finance ($63 billion per year in 2021–22) is considered adaptation finance. Recent efforts to better capture private finance for adaptation will help improve these assessments (CPI 2024). But despite these differences in scope and definition, it is clear that adaptation and development finance needs in developing countries are greater than current finance flows.

Improved resilience will enhance and accelerate long-term development and poverty reduction. Not only will it reduce the losses to climate change and natural hazards (a first dividend from resilience), it will also encourage more productive investments and behaviors, a benefit referred to as the "second dividend" of disaster risk reduction (Tanner et al. 2015; Heubaum et al. 2022).

Countries have not mainstreamed adaptation and resilience in their economic and development policies

KEY MESSAGE #2

A&R readiness assessments for 44 countries and economies identify major gaps and limits in current policies and systems, particularly in poorer countries. These include key gaps in implementing adaptation measures at sector level, addressing broader macrofiscal risks and implications, and monitoring and evaluation.

A&R readiness assessments in 44 countries[1] show that they have made progress in implementing A&R interventions, but most struggle to move to a whole-of-society approach. The assessment uses the Adaptation Principles framework (figure ES.3) and finds that preparedness varies significantly across countries, sectors, and domains (figure ES.4). Countries with higher income, more stable macroeconomic framework, more fiscal space, and lower debt levels are better able to respond to shocks, anticipate future risks and invest in adaptation and resilience. Their populations tend to have the tools and instruments they need to anticipate, adapt to, and cope with climate impacts and, as development strengthens countries' institutional development and governance capacity, they are more likely to include climate considerations in their economic and development decision-making. Development gaps, poverty, inequalities, macroeconomic instability, and institutional development and governance capacity are key constraints to adaptation and resilience.

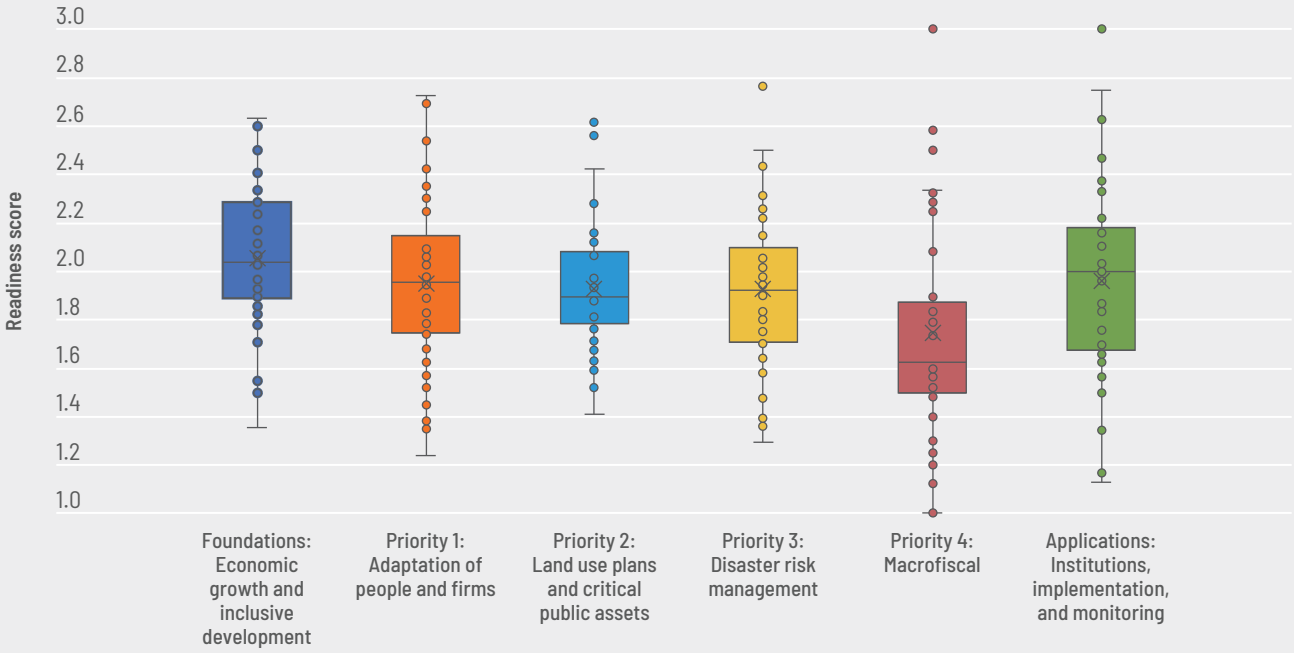
The assessment highlights three major gaps in mainstreaming A&R and suggests three ways to bridge these gaps and design a whole-of-society approach.

First, focus on institutions and implementation. Most, if not all, countries have established A&R priorities in various policy instruments—most commonly their national adaptation plans or nationally determined contributions (NDCs)—but these often diverge from sectoral development plans and do not consider existing challenges for policy action. A handful of the countries assessed have set up legal frameworks for climate adaptation and resilience. Notable examples include Colombia's strong and extensive institutional framework for climate change with two key climate laws, Uganda's National Climate Change Act of 2021, and Peru's Framework Law No 30754 on Climate Change. Many countries lack institutional arrangements for devolving and delegating responsibility and finance to local governments so they can lead efforts on the ground. Another key area for improvement lies in clarifying private actor responsibilities and aligning incentives for adaptation and resilience. Countries tend to perform relatively well on preparing their health care systems for shocks and pandemics, possibly due to the

[1] The country selection is based upon the completion of A&R readiness assessments as a key input to various World Bank Group Country Climate and Development Reports (CCDRs), and results from a World Bank Caribbean region report (Browne et al. 2021).

FIGURE ES.3. THE ADAPTATION PRINCIPLES FRAMEWORK

FIGURE ES.4. SUMMARY OF COUNTRY PERFORMANCE IN THE SIX A&R PILLARS



Source: World Bank staff calculations, based on World Bank A&R country readiness assessments
Note: Each indicator is assigned a score of 1 (nascent), 2 (emerging), or 3 (established) using a range of information sources and methods, including benchmarking against peer countries and expert judgment, and then aggregated with equal weight for each priority area and pillar. Each dot represents a country's average score in the corresponding pillar, with the mean represented by a cross and scores between the 25th and 75th percentiles represented in the shaded box.

▲ Caring for mangroves on the coast, Situbondo, Indonesia.
Credit: ©Sam Maulidna/ shutterstock.com

lessons learnt from the COVID-19 pandemic. But they lag in strengthening the resilience of their energy systems, public assets, and infrastructure; making land use and urban plans risk-informed; and increasing water security. Despite rapid urbanization, many countries lack the institutional frameworks, technical capacity, and finance they need to integrate climate resilience in urban and land use planning. Most also lack asset management systems, climate risk screening, an inventory of critical public assets, and sufficient budget allocation for climate-resilient infrastructure.

Second, think macro. Many studies note that adaptation action remains fragmented, local and incremental, with limited evidence of transformational adaptation and risk reductions (Berrang-Ford et al. 2021). The A&R readiness assessments confirm this finding and conclude that countries have made least progress in addressing macrofiscal issues. This highlights the technical and capacity challenges to identifying, quantifying, and managing macrofiscal risks posed by climate impacts, including risks to macroeconomic stability, public finances, debt sustainability, and the financial sector. Among emerging economies, Colombia remains a leader in this area and was the first Latin American country to carry out a climate stress test of its financial sector (World Bank Group 2023b). Many countries have made progress on incorporating climate risks in their national budget processes—for example, Senegal has a green budget. But most still need to develop a financial strategy to manage climate

and disaster risks, with clear emergency budget allocation guidelines and ex post financial assistance processes, a more reactive social protection system, and the development of appropriate financial instruments, such as insurance.

Third, monitor progress and learn from it. As countries progress with A&R action, having robust monitoring, evaluation, and learning systems in place is vital. But given the evolving nature of climate change dynamics and other socioeconomic factors that can exacerbate climate vulnerabilities or hinder climate action, monitoring and evaluating climate adaptation is inherently complex and challenging, and most countries have limited capacity in this area. A noteworthy exception is Uganda, one of the few countries that has developed an integrated monitoring, reporting and verification tool, which has been instrumental in enhancing coordination between public and private sector stakeholders on key areas of climate adaptation and mitigation action, including data sharing and tracking financial flows.

Private and public actors are stepping up A&R action and investments

KEY MESSAGE #3

While not always visible, there are strong examples of effective adaptation practices in all sectors, regions, and income levels. These provide lessons for delivering successful adaptation interventions in both the public and private sectors and offer opportunities to replicate and scale up proven solutions.

Despite major gaps, this report dispels the idea that no progress is being made. Given that climate change is often one among many considerations in an intervention's design and implementation, A&R actions are not always visible. Through a series of case studies, this report identifies a set of good practices that can be replicated, with appropriate adjustments to the local context, and scaled up across countries or sectors.

Private actors are stepping up their investments in resilience. Firms will invest in adaptation if it is relevant to their continued profitability and market position. But while adaptation can reduce costs and improve performance, there are persistent barriers to greater private investment. These include information asymmetries and knowledge gaps; difficulties monetizing resilience benefits; limited awareness; unclear metrics to measure success; coordination failure; and credit vulnerabilities that increase capital costs even for low-risk, high-return resilience investments. These barriers disproportionally affect small businesses and informal firms.

Investing in A&R solutions often increases revenue, but all firms face implementation challenges. Companies are increasingly implementing strategic interventions—such as regenerative agriculture, more resilient infrastructure designs, and climate risk stress-testing of financial portfolios—which not only increase resilience, but also improve efficiency and returns. Private sector initiatives and investments in resilience are often constrained by capacity issues, especially for small- and medium-size firms, and depend on a supportive policy and regulatory environment.

When adaptation solutions generate noneconomic gains, private actors need dedicated public support. When gains cannot be monetized, strategic coalitions and public-private partnerships help to mobilize resources. This is especially true in the infrastructure

sector, where private companies, government agencies, and nonprofit entities partner to pool resources and secure finance for resilience.

Companies are beginning to take a broader sustainability lens when implementing climate resilience. Firms are increasingly looking at risks and resilience in the context of broader sustainability challenges, including pollution, biodiversity, and greenhouse gas (GHG) emissions. They are also focusing on vulnerable communities, driven by business and ethical considerations.

In the public sector, governments and local authorities are increasingly promoting adaptation and resilience. A first selection of case studies in this report, summarized in table ES.2, emphasizes innovative interventions that are already showing results. Although these examples are not intended to be comprehensive or representative of all interventions, they demonstrate that significant action and investments are already taking place, with measurable results. They also highlight the diversity of interventions, the variability in indicators and metrics, and the challenges in systematically measuring their performance and impact and aggregating their results. It also confirms that adaptation and resilience present a whole-of-society challenge and need to be mainstreamed in all (public and private) decisions and policies.

View of Benjakiti Park, Bangkok, Thailand. Credit: © tonbluesman/ istock.com

TABLE ES.2. OVERVIEW OF CASE STUDIES ON PUBLIC SECTOR-LED A&R PROGRAMS

CASE STUDY	SECTOR(S)	CLIMATE HAZARDS/ RISKS	ADAPTATION POLICY/ PROGRAM	RESULTS/OUTCOMES	KEY TAKEAWAYS
Bangladesh: Building end-to-end hydromet services	Disaster risk management	Flood, cyclone	Improving the hydromet services, including all parts of the value chain, and establishing agrometeorological services for farmers	Reducing farmers' crop losses due to better weather forecasting from 4.11% to 0.82%	Modernizing hydromet services needs to address sector-specific needs along the entire downstream value chain to deliver actionable information and better decision-making
Pacific Island Countries: Programmatic, regional solutions for resilient transport	Transport, infrastructure	Cyclone, flood, landslide, sea level rise, coastal erosion	Regional framework that mainstreams climate considerations in transport projects in all segments of the transport infrastructure lifecycle	Increasing climate resilience in 11.2 km roads (140 km by 2030), airport, bridges, wharves; reducing maintenance expenditure by 20% and post disaster rehabilitation costs by 75%	In countries where resources and capacity are constrained, a regional, programmatic approach generates benefits across projects by improving management efficiency, reducing transaction costs, and sharing data and lessons learned
Brazil: Infrastructure investment to build drought resilience	Water, infrastructure	Drought	The First Water Cisterns program builds resilience among the poorest in the face of growing water stress and moves from relief and response to building sustainable coexistence with drought	Improving water availability; decreasing the risk of diarrhea episodes by 73%; improving birth weight, neonatal outcomes, and gender equality; delivering an approximate net gain of $200 per cistern	Promoting decentralized technologies and services and shifting from drought relief/response to building sustainable drought resilience improves water availability and quality
Albania: Creating an enabling environment to mobilize private investment	Energy, hydropower	Drought, flood	Government mandate to diversify energy sources, focusing on non-hydro renewable energy, and country's first large-scale solar photovoltaic project	Providing electricity to 66,000 households; creating jobs in community; contributing to NDC adaptation priority of climate-proofing energy infrastructure and reducing GHG emissions	The project's hybrid commercialization framework mitigates risks posed by public sector dominance in the energy sector and sets a model for future private sector participation
Bangladesh, Nigeria, Nepal, and Niger: Adaptive social protection to support poor and vulnerable people	Social protection, disaster risk financing	Flood, drought	Anticipatory and early response programs, including through national safety net programs, delivering social protection and financial inclusion by acting ahead of predicted hazards; preventing or reducing the adverse effects of shocks on lives and livelihoods before the impacts fully manifest	Helping alleviate short-term humanitarian need by reducing food insecurity: e.g. in Niger, the early transfers improve food security by 8%, consumption by 17.6%, and psychological well-being by 17.8%	Anticipatory action/ early response are more effective than a traditional, ex post response in helping people recover from climate shocks; they are also more impactful when integrated into comprehensive climate resilience strategies

TABLE ES.2. (cont.)

CASE STUDY	SECTOR(S)	CLIMATE HAZARDS/ RISKS	ADAPTATION POLICY/ PROGRAM	RESULTS/OUTCOMES	KEY TAKEAWAYS
India: Saving lives with heat-health action plans	Health, urban	Extreme heat	The Ahmedabad Heat Action Plan establishes key measures for both immediate and longer-term actions to reduce the public health impacts of extreme heat, through early warnings, community outreach, capacity building, and the adoption of cool roofs	Preventing 2,380 heat-related deaths in the first two years; reducing deaths on days with maximum temperatures of 47°C by 88%	Effective emergency response to extreme heat requires clearly defined roles and responsibilities across departments, elevated public awareness, and accessible information
Philippines: Comprehensive financial preparedness	Disaster risk financing	Cyclone, flood, landslide	Disaster risk finance and insurance (DRFI) strategy that ensures sound fiscal health at national government level, improves financial resilience at local government level, and protects financial preparedness at individual level	Mobilizing the private sector through insurance; improving fiscal resilience; protecting more households and farmers, especially the most vulnerable; increasing insurance uptake among farmers to one-third	Implementing a comprehensive risk-layering strategy takes time; strong ownership is crucial for continuity; and engaging the private sector ensures DRFI instruments protect more people
Vanuatu: Climate and disaster-resilient development	Multiple	Cyclone, flood, landslide	Government's multipronged approach to incorporate climate and disaster risk and resilience in policies, legislations, climate-informed investments, and land-use planning through institutional strengthening and policy reform	Increasing policy cohesion for climate adaptation and disaster risk management; strengthening resilience in project design and standards across various sectors	Achieving policy coherence and coordination is a challenge and requires continued government leadership and sustained/long-term commitments from all stakeholders
Guinea: Supporting decentralization and strengthening local government for effective local climate action	Local governance	Flood, sea level rise, extreme heat	Capacity building for climate-resilient local development through decentralization and performance-based resource transfer to integrate participatory climate risk diagnosis and prioritization into local development planning	Improving local government capacity to identify and respond to climate risks	Institutionalizing the local government structure; building national and local government capacity and knowledge; international fund accreditation readiness; and integrating actions with the mining sector to unlock more funding

Young girls in the Zanzibar sea water. Credit: © Zurijeta/ shutterstock

These promising examples of innovation and effectiveness from both public and private sector actors are already helping communities and countries better prepare and respond. At the very least, they offer an opportunity to better understand gaps and barriers, and taken together, for replication and learning. This combination offers a way forward: once countries and communities have defined their own priorities according to their objectives, needs, and risks, and have clearly identified and selected key gaps, they can use the innovations and examples summarized in this report to develop their own solutions to accelerate progress toward more inclusive and resilient development, higher adaptation capacity, and better and safer lives.

This report is only a start. Realizing the full impact of policies, private sector initiatives and other programs takes time, and it will take decades to fully implement some interventions and measure their benefits. The World Bank aims to continue collecting, analyzing, and sharing examples of successful (and less successful) climate A&R policies or interventions to inform decision-making across the world. Through this work, it hopes to spark more discussion among governments, private sector actors, international financial institutions, development partners, and civil society, encouraging them to engage in the journey of broader coordination and collaboration to support more rapid, inclusive, and resilient development.

Introduction

The growing and unequal risks from climate change

◀ PHOTO: Farmer inside greenhouse in Mexico. Credit: © MStudioImages/istock.com

Urgent and ambitious actions are needed to enhance the resilience and adaptive capacity of people, businesses, communities, economies, and ecosystems. The Paris Agreement's Global Goal on Adaptation (GGA) establishes aspirations to enhance adaptive capacity, strengthen resilience, and reduce vulnerability to climate change, particularly for vulnerable populations and communities. The United Arab Emirates' Framework for Global Climate Resilience, adopted at the 28th Conference of the Parties (COP28), provides further structure for developing the GGA and outlines goals for key sectors and adaptation policy processes, creating a strong foundation for scaling up national and global action on adaptation and resilience (box 1).[2]

BOX 1.

Defining Adaptation and Resilience (A&R)

Adaptation refers to actions taken to adjust systems, behaviors, or structures in response to climate change or climate change and variability, aiming to reduce vulnerability and take advantage of potential benefits. It often includes specific strategies, such as altering agricultural practices, building flood defenses, or designing more heat-resistant infrastructure. Sometimes, adaptation refers specifically to the change in climate conditions due to man-made greenhouse gas (GHG) emissions, but it is increasingly defined as including the actions to reduce impacts from climate-related hazards, even those that predate human-caused climate change.

Resilience refers to the capacity of a system—natural, social, or economic—to absorb, recover from, and adapt to shocks while maintaining essential functions. Definitions and practices of resilience vary across academic disciplines.

Adaptation and **resilience** are closely related concepts, as implementing adaptive measures enhances the resilience of people, firms, communities, and countries. Building adaptation and resilience needs to be an iterative and dynamic process as climate risks evolve.

Source: IPCC 2022

[2] The framework outlines goals for seven thematic areas—for water, food, health, ecosystems and biodiversity, infrastructure and human settlements, poverty and livelihoods, and cultural heritage—and four adaptation policy process-related targets to help all parties establish impact, vulnerability and risk assessments, adaptation planning and implementation processes, and monitoring, evaluation and learning by 2030 (https://unfoundation.org/what-we-do/issues/climate-and-energy/uae-framework-for-global-climate-resilience/).

Climate change and its impacts

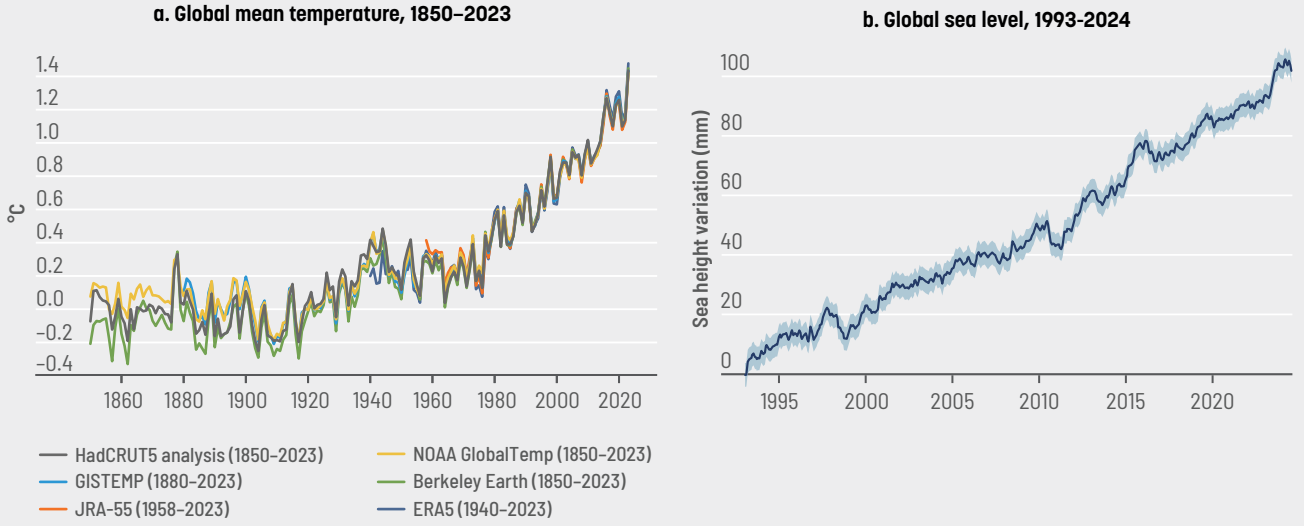
The Earth's climate system is experiencing unprecedented and rapid changes due to human activities, with profound impacts on human well-being, communities, and the world's natural systems. The annual average global temperature continues to rise, and the rate of warming is accelerating (figure 1a). The decade from 2014 to 2023 was the warmest on record, and 2023 recorded a global mean surface temperature of 1.45°C (± 0.12°C) above preindustrial levels (WMO 2023, 2024).[3] The Arctic is warming at about twice the global average rate, driving ice melt and sea level rise. In 2023, the global average sea level was also at a new record, at 101.4 millimeters above 1993 levels (figure 1b). In 2023, ocean heat content also reached its highest level and over 90 percent of the global ocean experienced heatwave conditions (WMO 2024).

GHG emissions associated with human activities are the primary driver of climate change, and global temperatures will continue to rise until the world achieves net zero emissions. Although country commitments are increasingly aligned with the Paris Agreement temperature goals and clean energy is rapidly expanding, GHG emissions are not declining quickly enough to avoid the worst impacts of a changing climate. Scenario analyses suggest that, with current policies and technology development, global mean temperatures could rise by 3.1°C by the end of the century. Policy pledges and net zero emission target commitments would lower temperature rise to 1.9°C, which is close to the Paris Agreement's long-term goal of keeping temperature increase to well below 2°C while also pursuing efforts to limit warming to 1.5°C.[4]

[3] https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature.

[4] United Nations Environment Programme (2024). *Emissions Gap Report 2024: No more hot air ... please!* Nairobi. https://doi.org/10.59117/20.500. 11822/46404.

FIGURE 1. CHANGES IN GLOBAL MEAN TEMPERATURE AND SEA LEVEL



Sources: Panel a: World Meteorological Organization, using consolidated global temperature datasets for 2023; panel b: NASA's Goddard Space Flight Center, Satellite sea level observations, 1993–2024

▲ Mountain valley in low clouds. Credit: © Denis Belitsky | shutterstock

The warming trend has already led to more frequent and intense climate extremes—including heatwaves, droughts, storms, floods, and wildfires—with vulnerable countries, people, and communities disproportionately affected. The world is experiencing record-breaking extreme weather- and climate-related events, and their impacts are undermining progress toward the Sustainable Development Goals (WMO 2023). Over the past 20 years, extreme weather events have cost the world $2.8 trillion.[5] Heatwaves have gripped many countries in Asia, North America, Europe, and the Middle East. One study estimates that, between 2000 and 2019, extreme heat caused 489,000 deaths annually, with half occurring in Asia (Zhao et al. 2021). In August 2024, flash floods and monsoons affected nearly 6 million people in Bangladesh, destroying infrastructure and causing hundreds of millions of dollars in losses.[6] In Eastern Africa, cyclones, heavy rainfall, and flooding during the 2024 monsoon season affected over 1.6 million people, displacing hundreds of thousands of people and communities in Burundi, Kenya, Rwanda, Somalia, and Ethiopia.[7] Meanwhile, a prolonged drought in Southern Africa decimated almost half of Zambia's maize-growing area, causing crop failures and threatening food security (UNICEF 2024). Children are extremely vulnerable to climate risks, with long-term impacts on economic and human capital development (UNICEF 2023).

The Country Climate and Development Reports (CCDRs), a core World Bank diagnostic, show that the economic impacts of climate change are expected to worsen without strong global efforts to reduce GHG emissions (World Bank

[5] https://www.weforum.org/agenda/2023/10/climate-loss-and-damage-cost-16-million-per-hour/.

[6] https://reliefweb.int/report/bangladesh/climate-change-exacerbated-flash-floods-bangladesh.

[7] https://disasterphilanthropy.org/disasters/2024-east-africa-flooding-cyclone/#:~:text=Months%20of%20heavy%20rain%20due,%2C%20Tanzania%2C%20Burundi%20and%20Somalia.

Group 2023d). These estimates are consistent with the literature: with historically observed levels of adaptation, warming of ~4°C may cause a 10–23 percent decline in annual global GDP by 2100 relative to global GDP without warming, due to temperature impacts alone (O'Neill et al. 2022; Burke, Hsiang and Miguel 2015; Kahn et al. 2019; Kalkuhl and Wenz 2020). While the estimates from CCDRs capture some of the most critical impact channels—such as labor productivity, crop yields, water availability, and risk of disaster—the impacts of climate change are wide-ranging and complex, and the cascading impacts across sectors and systems are not fully captured. Feedbacks between continued deforestation and climate change in the Amazon Basin, for example, could lead to an ecosystem tipping point that would result in major changes in water availability and climate across all of South America. For Brazil alone, the economic impacts of reaching such a tipping point could amount to $184 billion (about 10 percent of GDP) by 2050 (World Bank Group 2023a).

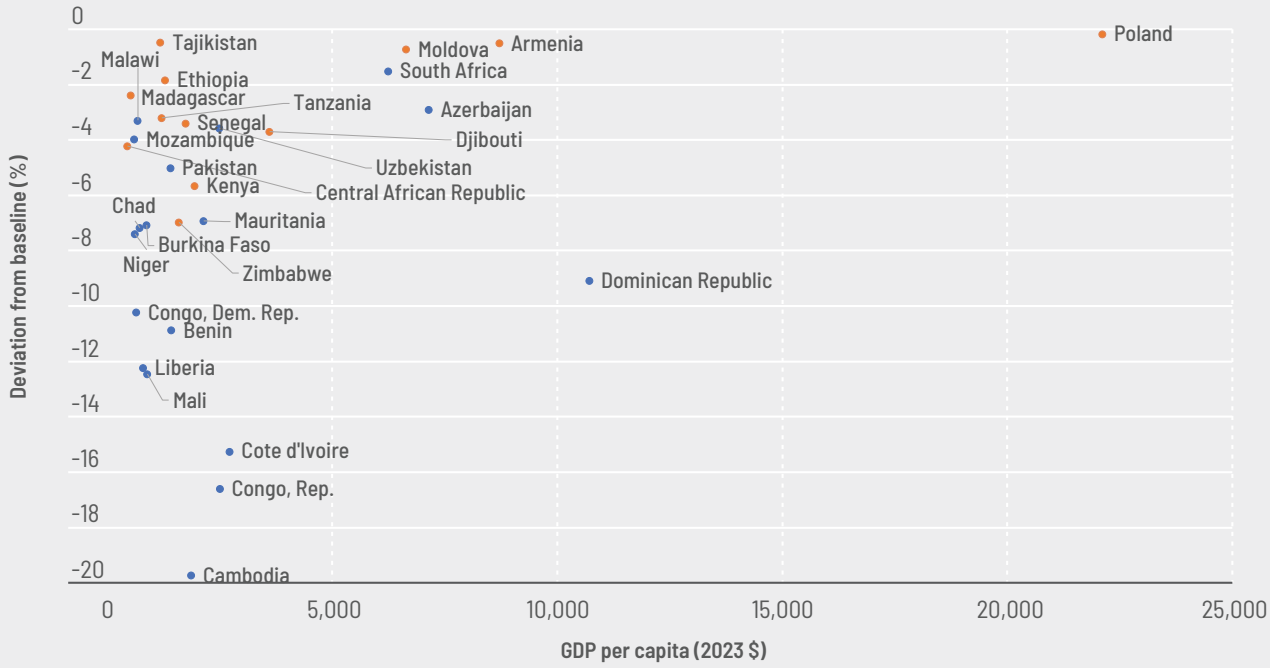
Impacts are larger on poor and vulnerable countries, communities, and people

The higher vulnerability of lower-income countries to climate change is well established. The Intergovernmental Panel on Climate Change (IPCC) concludes that, assuming global warming of ~4°C by 2100, historical adaptation levels, and high vulnerability, losses across Sub-Saharan Africa may reach 12 percent of GDP by 2050 (Baarsch et al. 2020) and 80 percent by 2100 (Burke, Hsiang and Miguel 2015), much higher than in higher-income countries. There is evidence that warming has slowed down the convergence of income between countries in recent decades (Diffenbaugh and Burke 2019), and future impacts may halt or even reverse this trend during this century, owing to high sensitivity of lower-income countries (Burke, Hsiang and Miguel 2015; Pretis et al. 2018; Baarsch et al. 2020).

The CCDRs also highlight the higher vulnerability of poor countries, driven by their reliance on agriculture for income and employment, exposure of physical and outdoor work to high temperatures, and their often-hotter climates. Under a hot/dry scenario, climate change tends to have a more negative impact on labor productivity in countries with lower per capita GDP (figure 2). As discussed in the third CCDR summary report (World Bank Group 2024), the median loss of productivity in CCDR countries is 6.2 percent in low-income countries (LICs), 5.3 percent in lower-middle-income countries (LMICs), 1.5 percent in upper-middle-income countries (UMICs), and 0.2 percent in high-income countries (HICs).[8] This is driven by two dimensions: country economic structures, with LICs having more outdoor physical labor due to the large share of unmechanized agriculture; and climate conditions in LICs, which tend to be hotter and more humid than those in richer countries, on average. These impacts on labor productivity are also magnified by other impacts that affect poorer countries the most. In LICs such as the Democratic Republic of Congo and Côte d'Ivoire, GDP could be reduced by 13 percent by 2050 under pessimistic scenarios (World Bank Group 2023d).

[8] Simple averages across countries gives similar results, but with a smaller difference between LICs and LMICs: 6.4%, 7.5%, 2.9%, and 0.2% for LICs, LMICs, UMICs, and HICs, respectively.

FIGURE 2. PROJECTED TOTAL LABOR PRODUCTIVITY IMPACT DUE TO HEAT STRESS IN CCDR COUNTRIES BY 2050, UNDER A HOT/DRY FUTURE

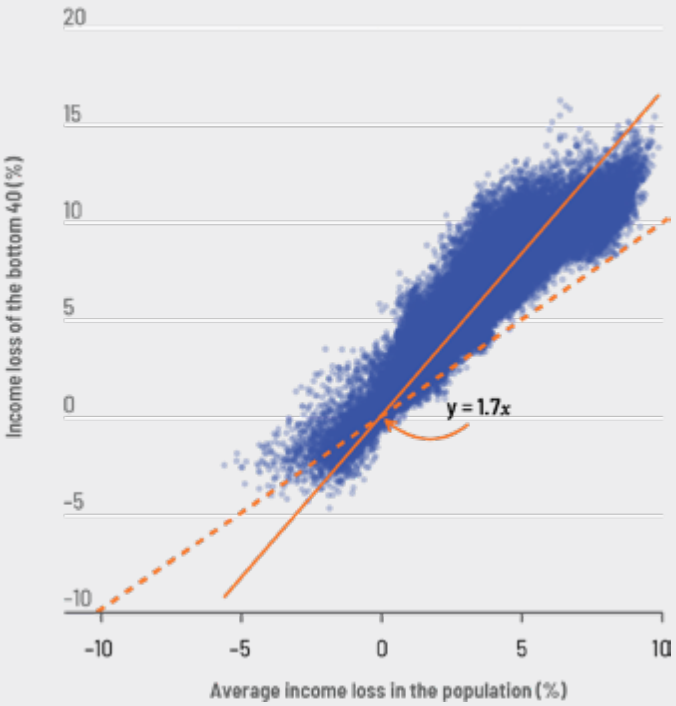


Notes: This figure presents aggregated estimates for the agriculture, industry, and services sectors, weighted by the value-added share of each sector. An updated methodology for estimating changes in labor productivity, applied in orange countries, includes adjustment for solar radiation and other relevant factors. This improvement has resulted in generally lower estimates of heat stress impacts compared to the previous methodology, which was used in blue countries.

Within countries, poorer people are also more vulnerable to natural hazards and climate change (Hallegatte, Fay and Barbier 2018; Hallegatte and Rozenberg 2017). Evidence based on modeling and empirical work shows large impacts on both poverty and inequality: plotting income losses at the aggregate level (x-axis) and for the 40 percent of households with the lowest income (y-axis), figure 3 shows that the expected impacts of climate change on the bottom 40 percent are on average 70 percent larger than those on the average population. Others have reached similar conclusions. At the global scale, Azzarri and Signorelli (2020) find that flood shocks result in a 17-percentage point increase in extreme poverty in Sub-Saharan Africa and predict that increased rainfall and higher temperatures could result in dramatic increases in extreme poverty rates by up to 30 percentage points. Another analysis, using the Subnational Poverty and Inequality Database covering 1,594 subnational units from 134 countries and spanning 2003 to 2019, finds that changes in temperature have a large impact on poverty at the subnational level (Dang, Hallegatte and Trinh 2024). Specifically, a 1°C increase in temperature can result in around 6 percent increases for different measures of chronic poverty.

Poverty is not the only driver of vulnerability. Multiple and often overlapping factors—including livelihoods, health, education, skills, life stage, social cohesion, and exposure to fragility, conflict, and violence—influence the impact of climate change on people. In South Africa, for example, multidimensional exclusion in the

FIGURE 3. INCOME LOSSES FOR THE POOREST 40 PERCENT IN EACH COUNTRY AND SCENARIO



Source: Hallegatte and Rozenberg 2017
Note: The figure shows the income losses for the poorest 40% in each country and scenario, plotted against aggregated income losses in 1,200 scenarios in 92 countries.

North-West and Limpopo provinces worsens the impacts among populations who are more exposed to temperature increases and droughts than the national average (World Bank Group 2022e). In Uzbekistan, an already water-stressed country, women are particularly vulnerable to increased water scarcity, as agricultural work represents a larger share of their employment, especially in the cotton sector (World Bank Group 2023e).

Low-income population are at high risk from climate-related hazards

A new indicator, included in the World Bank Group's corporate scorecard,[9] estimates the fraction of the global population at high risk from climate-related hazards (Hill et al., forthcoming). This indicator combines the number of people who are both exposed and highly vulnerable to climate-related hazards globally (figure 4).

The approach overlays spatial climate hazard datasets with household data[10] to count people who are both exposed to a set of key climate-related hazards, such as floods, droughts, heatwaves, and cyclones, and have a propensity to be adversely affected or unable to cope with the impacts. People are counted as *at high risk* if they are exposed to at least one hazard and highly vulnerable on at least one dimension of vulnerability—for example, due to low education level, or a lack of income, access to basic services, social protection, or financial instruments. This proposed methodology is a first step, which will be improved over time in both scope and precision, along the dimensions of coverage, timely updates, and overall methodology.

Estimates from 103 countries, which make up 86 percent of the global population, show that 1.2 billion people are exposed to at least one climate-related hazard and highly vulnerable on at least one dimension in 2021 (figure 5). Driven by very high rates of exposure to heatwaves, the population of South Asia has the highest exposure to climate shocks (almost 90 percent) and around 30 percent of the population is at high risk. In Sub-Saharan

[9] http://scorecard.worldbank.org/.
[10] Estimating the share of households that are vulnerable on any dimension requires the "fusing" of different data sources, since not all dimensions are available from the same household survey. While data on income, education, and access to water and electricity are mostly available from the same survey in the Global Monitoring Database (GMD), data on social protection and financial inclusion are based on other surveys (ASPIRE and FINDEX, respectively).

FIGURE 4. FRAMEWORK FOR IDENTIFYING PEOPLE AT HIGH RISK FROM CLIMATE-RELATED HAZARDS

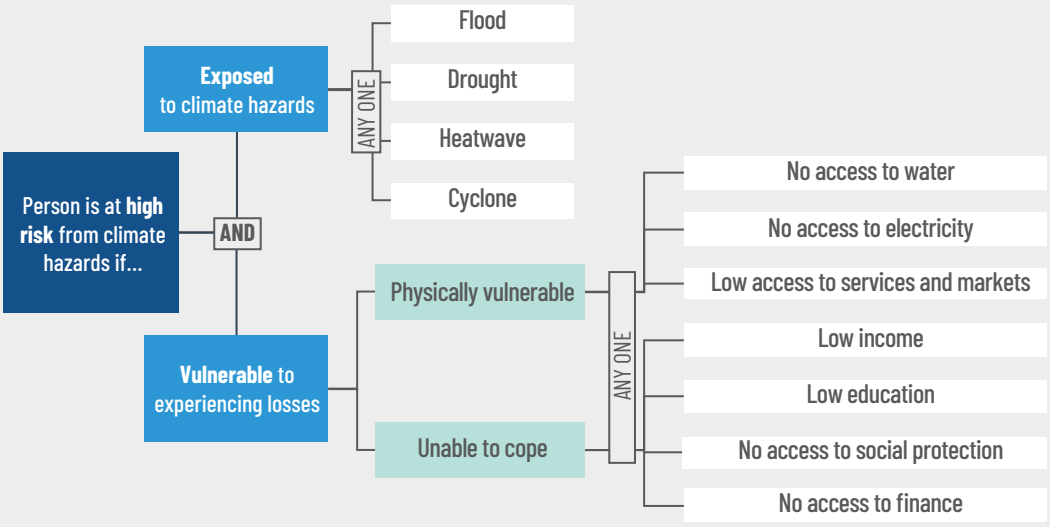
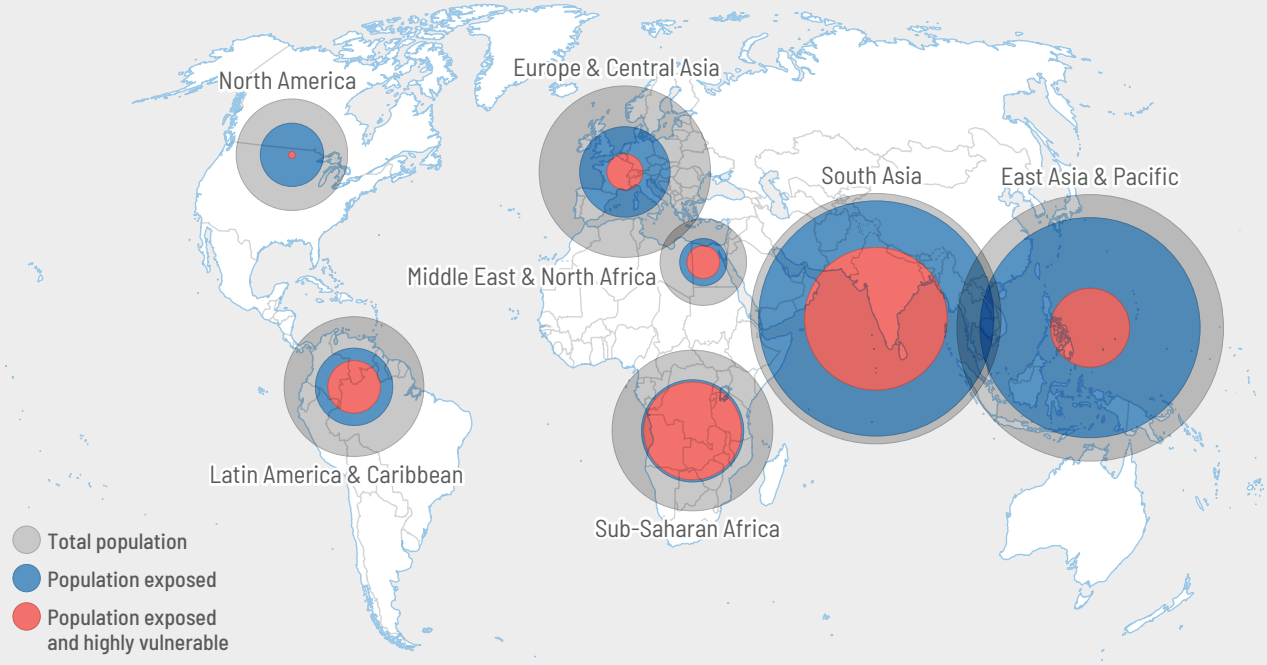


FIGURE 5. SHARE OF POPULATION THAT IS EXPOSED AND HIGHLY VULNERABLE BY REGION, 2021

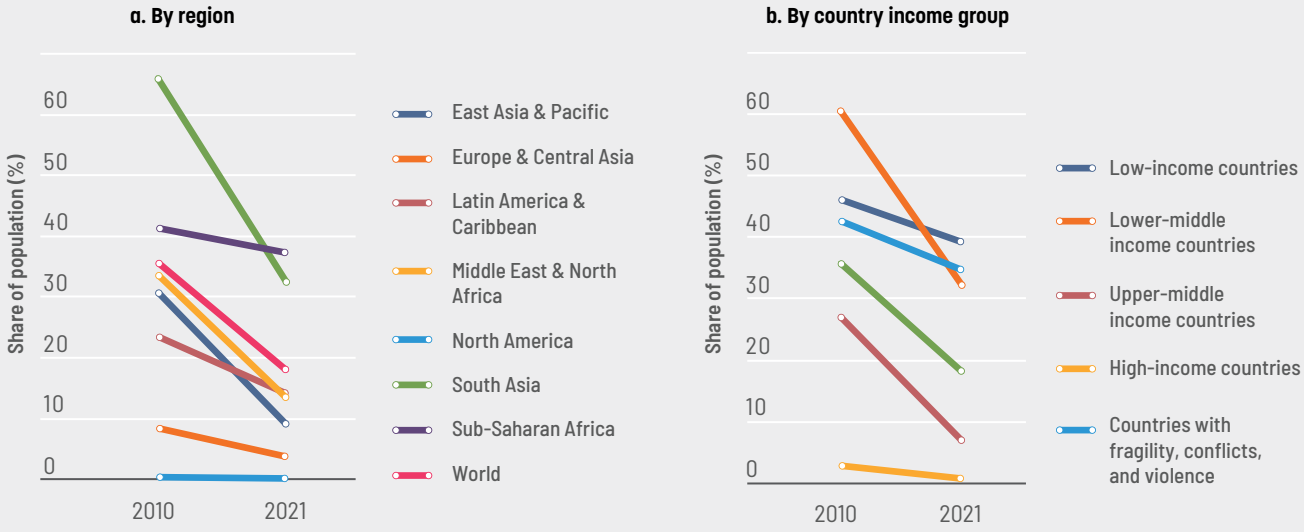


Source: World Bank staff calculations using World Bank Group Scorecard indicator data on *percentage of people at high risk from climate-related hazards* (https://scorecard.worldbank.org/); Hill et al. (forthcoming).

Africa, around 40 percent of the population is exposed to climate shocks, and almost all of this population is considered at high risk, revealing the very urgent challenges faced by these two regions to reduce their extreme vulnerability to climate change. In contrast, in North America and Europe and Central Asia, which comprise many HICs, almost one-third of the population is exposed, but well under 5 percent is considered at high risk. These results reveal that, although higher-income countries have relatively high rates of exposure to climate shocks, their people are better equipped to adapt to and recover from climate shocks and therefore are not considered extremely vulnerable.

The fraction of people at high risk from climate-related hazards halved between 2010 and 2021, from 36 to 18 percent of the global population, demonstrating global progress and illustrating the benefits of development for resilience (figure 6). East Asia and the Pacific made the largest improvements of all regions, due to significant progress in development, poverty reduction, human capital development, and financial inclusion. In 2010, two-thirds of South Asia's population was at high risk—the highest among all regions—but thanks to large strides in financial inclusion, electricity access, and poverty reduction, this figure halved by 2021. Similar progress has been seen in Latin America and the Caribbean, the Middle East, and North Africa, despite population growth. While Sub-Saharan Africa has also seen progress across most vulnerability dimensions, the number of extremely vulnerable people is still high and the share of the population at high risk has not decreased much over the past 10 years.

FIGURE 6. SHARE OF POPULATION AT HIGH RISK FROM CLIMATE-RELATED HAZARDS, 2010–21



Source: World Bank staff calculations using World Bank Group Scorecard data on *percentage of people at high risk from climate-related hazards* (https://scorecard.worldbank.org/); Hill et al. (forthcoming)
Note: Countries are excluded if the underlying survey data are not within a three-year window around the reporting year.

This report

This report explores the priorities for adaptation and resilience in the context of other pressing development challenges. Chapter 1 provides a framework for mainstreaming adaptation and resilience within other key development challenges. It also identifies the vital role of private sector actors—including households and firms—in building resilience through their choices and investments, and the need for a whole-of-society approach to ensure enabling conditions and appropriate coordination and synergies across actions undertaken by people, firms, local authorities, public agencies, and the government. Chapter 2 presents insights from systematic assessments of countries' preparedness and readiness to adapt to climate change and identifies major gaps and priority actions to achieve resilient development for all. Chapter 3 uses selected case studies to highlight the rapid acceleration in A&R action by private and public actors, showing that progress is happening. These examples of successful actions provide information on opportunities to replicate and generalize what works, opening the door to a rapid scale-up of adaptation action across the world. A brief section concludes the report.

CHAPTER 1

Adaptation and resilience as a development imperative

◀ PHOTO:
A Hmong woman on terraced rice fields, YenBai, Viet Nam. Credit: © Surachart Sukhum/ istock.com

The growing threat from climate-related hazards and climate change to development, and the disproportionate effects on poorer people, make adaptation action an urgent imperative. However, LICs and LMICs face a broad range of development challenges and hard trade-offs in allocating resources toward them. This chapter proposes a framework to identify the most important priorities for reducing the future impacts of climate-related hazards and climate change, arguing that mainstreaming climate risks into development is the surest way to manage trade-offs and capture synergies between resilience and other important development objectives. In particular, the higher vulnerability of poorer people means that adaptation can be successful only if it contributes to the broader development agenda.

1.1. Development, adaptation, and resilience are inseparable

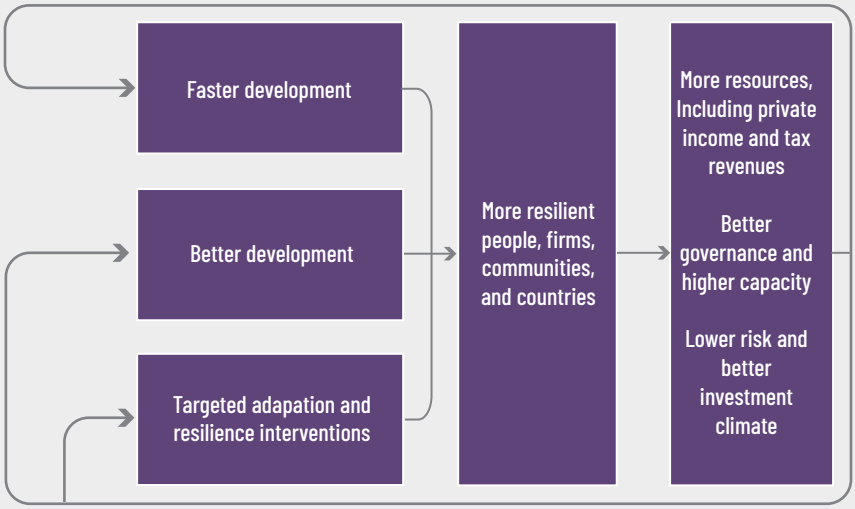
Minimizing the present and future impacts of, and building resilience to, climate change requires three key parallel achievements: faster development, better development, and targeted adaptation interventions (figure 7). This section covers these in turn.

1.1.1. Faster development: closing development gaps is fundamental to boost resilience

Without faster development and achieving the Sustainable Development Goals, LICs and LMICs will not be able to ensure their populations are resilient to and able to cope with climate change impacts. No adaptation interventions can make households resilient if they do not have access to basic infrastructure services, such as energy and improved water, financial instruments, such as saving accounts and emergency borrowing, or basic social services, such as health care.

Access to electricity, safe drinking water, mobility, financial instruments, and markets is critical for coping with extreme events and climate change impacts. For example, access to reliable and safely managed drinking water can protect communities from the health impacts of contaminated flood or storm water or a lack of water due to drought. Having access to electricity enhances multiple dimensions of household and community resilience, such as the ability to use cooling appliances to alleviate heatwaves and access to early warnings (Perera et al. 2015). Financial services—such as savings, credit, insurance, and remittances—are essential tools that enhance a household's ability to manage risks and recover from shocks (Clarke and Dercon 2016; Jensen, Barrett and Mude 2017; Bastagli et al. 2019; Zetterli 2023), while access to markets and quality infrastructure can help people diversify their incomes, access information and technology, and improve productivity (Dercon et al. 2009; Asfaw, Pallante and Palma 2018).

FIGURE 7. FRAMEWORK FOR MAINSTREAMING ADAPTATION WITHIN DEVELOPMENT

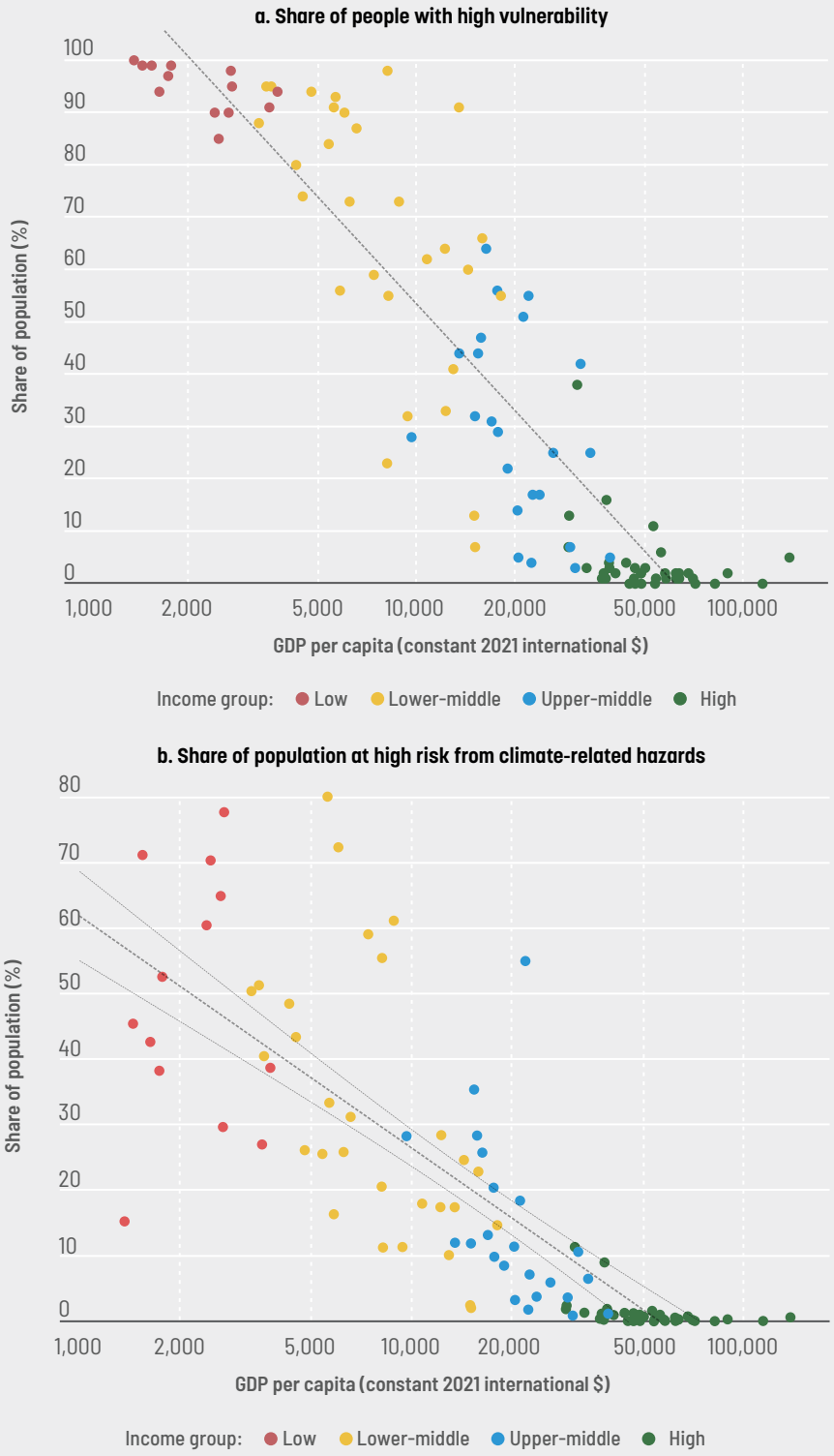


As countries develop, they also enhance the adaptive capacity of their people and communities. Research has consistently shown that households with a higher level of education have a better understanding of, and ability to process, risk information such as weather forecasts and early warnings (Mileti and Sorensen 1990; Hoffmann and Muttarak 2017). More educated individuals are also likely to assess and respond to risks more effectively, making them better prepared to cope with natural hazards and weather shocks (Helgeson, Dietz and Hochrainer-Stigler 2013; Muttarak and Pothisiri 2013; Muttarak and Lutz 2014). In Ethiopia and Bangladesh, children whose mothers have completed primary education do not suffer from stunting as a result of drought, unlike those whose mothers have no formal education or did not complete primary education (Dimitrova 2021; Le and Nguyen 2022).

Development gaps matter, particularly when considering extreme levels of risk to climate shocks. This is illustrated by the new World Bank indicator that measures the fraction of the population at high risk from climate-related hazards. Looking at the indicator's vulnerability dimension, the fraction of the population with high physical vulnerability or low ability to cope with and adapt to climate risks is highly correlated with GDP per capita: each 10 percent increase in GDP per capita corresponds to a 2.8 percentage point drop in the share of the population that is highly vulnerable to climate-related hazards (figure 8a). As a result, when vulnerability information is combined with exposure to various climate-related threats, the population at high risk from climate-related hazards also declines with income: a 10 percent increase in GDP per capita decreases the fraction of people at high risk by 1.5 percentage points (figure 8b). This means that a 10 percent increase in income could reduce the global population at high risk by almost 100 million people.

New health clinic in the community of Djodjo, in Mozambique. Credit: © UNCDF/Souza Domingos 2024.

FIGURE 8. SHARE OF PEOPLE WITH HIGH VULNERABILITY TO, OR AT HIGH RISK FROM CLIMATE-RELATED HAZARDS



Source: World Bank staff calculations, using World Bank Group Scorecard data on percentage of people at high risk from climate-related hazards (https://scorecard.worldbank.org/); Hill et al. (forthcoming)

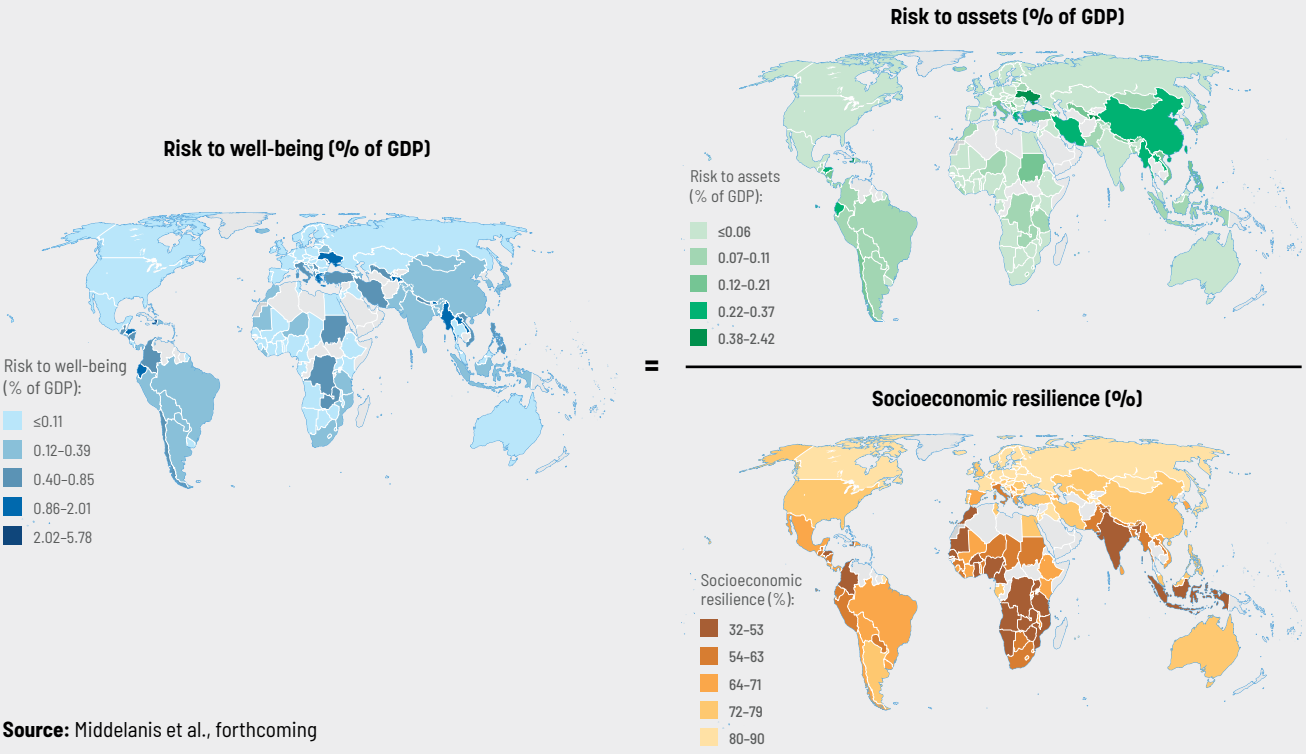
Other modeling approaches and risk indicators yield similar results, highlighting the higher vulnerability of poorer countries. One example is the estimate of well-being risks based on the global model developed in Hallegatte et al. (2016) and Walsh and Hallegatte (2020). An updated assessment is proposed in Middelanis et al. (forthcoming) building on the Coalition for Disaster Resilient Infrastructure's estimates of hazard-related asset risks (CDRI 2023).

This analysis defines *socioeconomic resilience* as the ability to experience asset losses without large well-being losses. The higher the socioeconomic resilience, the higher the ability to cope with physical destruction from disasters. In other words, a population with infinite socioeconomic resilience can experience any level of asset losses without any impact on well-being, while a population with zero socioeconomic resilience would experience an infinite loss in well-being, even for the smallest asset loss.

$$\text{Well-being losses} = \frac{\text{Asset losses}}{\text{Socioeconomic resilience}}$$

The socioeconomic resilience estimates, based on household surveys and population characteristics, consider people's income but also their income diversification and sources, liquid savings, access to emergency borrowing, social protection coverage, and their government's ability to provide post-disaster support. There is a strong correlation between socioeconomic resilience and GDP per capita, and a 10 percent increase in GDP per capita boosts resilience by 0.8 percentage points, on average. This result, with a large dispersion of countries at similar income levels, suggests that overall economic development is an important factor in improving a country's resilience, even

FIGURE 9. RISK TO ASSETS AND WELL-BEING, AND SOCIOECONOMIC RESILIENCE ACROSS THE WORLD

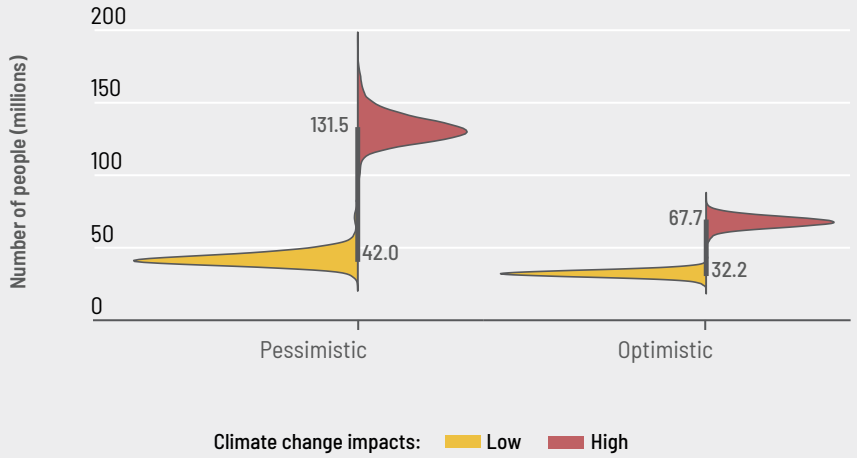


Source: Middelanis et al., forthcoming

though it is not the only driver. Figure 9 shows the results across the world.

Expanding the analysis from climate-related hazards to other climate change impacts also illustrates that faster development and better basic service provision build resilience and reduce climate vulnerability. When considering the impact of climate change, as well as climate-related hazards, on health, food production and prices, and labor productivity, a World Bank analysis finds that an optimistic development scenario (in terms of productivity growth, inequality, and access to services) reduces the additional number of people living in extreme poverty due to climate change from more than 130 to around 70 million (Hallegatte et al. 2016; Jafino et al. 2020). The analysis illustrates the importance of the baseline development assumption: an optimistic development scenario, doubling the LIC and LMIC GDP on average, could halve the number of people falling into poverty due to climate change in 2030 (figure 10). These numbers are indicative only, since the scenarios are not representative of the full set of possible futures, but they highlight the role of development in determining vulnerability.

FIGURE 10. ADDITIONAL PEOPLE LIVING IN EXTREME POVERTY DUE TO CLIMATE CHANGE BY 2030, UNDER TWO CLIMATE SCENARIOS



Source: Jafino et al. 2020

Income levels only explain a fraction of the differences in risk across countries. If risk is measured by direct economic losses—such as asset losses due to climate-related hazards, as estimated by the CDRI (2023)—income per capita has almost no effect on relative risk levels (expressed in percentage of GDP). Analyses of the historical record of disaster losses reach similar results, with losses growing at a similar rate as GDP (Hallegatte 2017; Pielke 2020).

GDP per capita plays a more important role when measuring macroeconomic or poverty impacts of climate change, well-being impacts from natural hazards, or the population living at high risk from climate-related hazards. Macroeconomic modeling for CCDRs finds that a 10 percent increase in GDP per capita is associated with a reduction by 0.2 to 0.3 percentage points in the impacts of a selected set of climate change impacts

(World Bank Group 2024). Even though absolute asset losses increase with income, a 10 percent increase in GDP per capita is associated with a 2.4 percent reduction in well-being losses (as a share of GDP), thanks to higher resilience (figure 14). As already illustrated in figure 8b, the effect of income is even more important when considering risk metrics that focus on more extreme levels of risk or vulnerability. As mentioned earlier, a 10 percent increase in GDP per capita corresponds to a 1.5 percentage point decline in the share of the population at high risk from climate hazards. Unsurprisingly, impacts on poverty are also highly dependent on economic growth and the development path. Using estimates based on the World Bank's *Shock Waves* model, faster development could avoid half the poverty impact of climate change by 2030, with a 10 percent increase in country-level GDP leading to a 5 percent reduction in the number of people living in poverty due to climate change in 2030 (Jafino et al. 2020). Importantly, these relationships are not causal and direct. It is not only the increase in income that boosts resilience and reduce risks, but all the changes that come with it, from financial inclusion to better infrastructure services.

TABLE 1. A 10 PERCENT INCREASE IN GDP PER CAPITA IS ASSOCIATED WITH IMPROVEMENTS IN VARIOUS RISK OR RESILIENCE METRICS

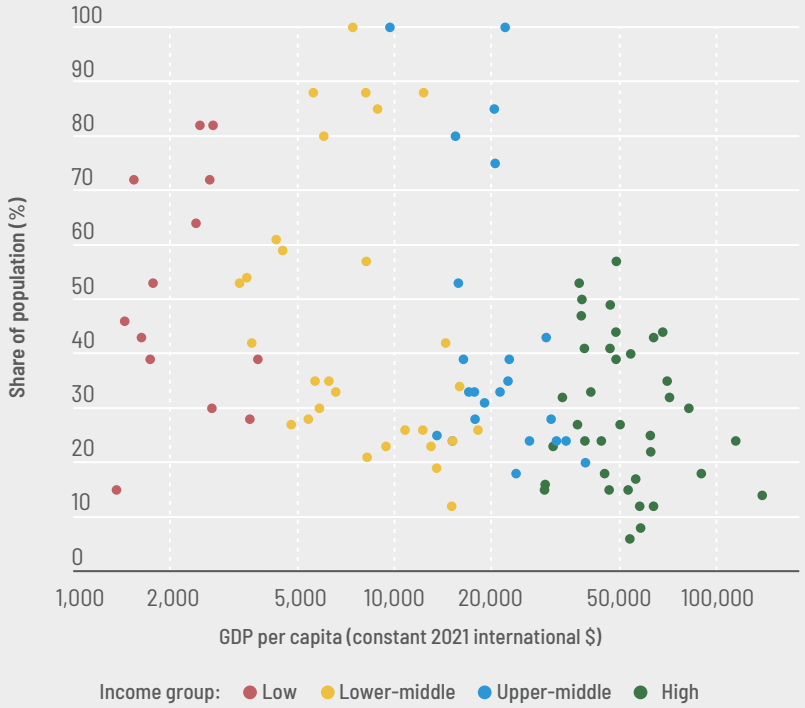
RISK OR RESILIENCE METRIC	CHANGE	BASED ON
Proportion of people highly vulnerable to climate-related hazards	2.8 percentage point reduction	http://scorecard.worldbank.org/; Hill et al. (forthcoming)
Proportion of people at high-risk from climate-related hazards	1.5 percentage point reduction	
Absolute asset losses (in $ per capita) from natural disasters	8.6 percent increase	CDRI (2023)
Relative asset losses (in % of GDP) from natural disasters	1.2 percent reduction (not significantly different from zero)	
Socioeconomic resilience from natural disasters	0.8 percentage point increase	Middelanis et al. (forthcoming)
Absolute well-being losses (in $ per capita) from natural disasters	7.4 percent increase	
Relative well-being losses (in % of GDP) from natural disasters	2.4 percent reduction	
Number of people falling in extreme poverty in 2030 due to climate change	5 percent reduction	Jafino et al. (2020)
Expected GDP losses due to (a subset of) climate change impacts in 2050	0.2 to 0.3 percentage point reduction	World Bank Group (2024)

1.1.2. Better development: not all development builds resilience

Although more development is a requisite for more resilience, it is not sufficient on its own: building resilience also requires better, more resilient, development. As discussed in section 1.1.1, the impact of GDP per capita on expected asset losses is limited (and not statistically significant). In particular, there is much weaker correlation between exposure and GDP per

capita (figure 11). Exposure seems to be primarily determined by factors such as geography, latitude, topography, and how (not whether) development takes place. Within this subset of around 100 countries, the lower level of exposure in HICs is largely driven by lower temperatures in extra-tropical countries, which make them less exposed to heatwaves and extreme heat.

FIGURE 11. SHARE OF POPULATION EXPOSED TO ANY CLIMATE HAZARD, BY COUNTRY INCOME GROUP

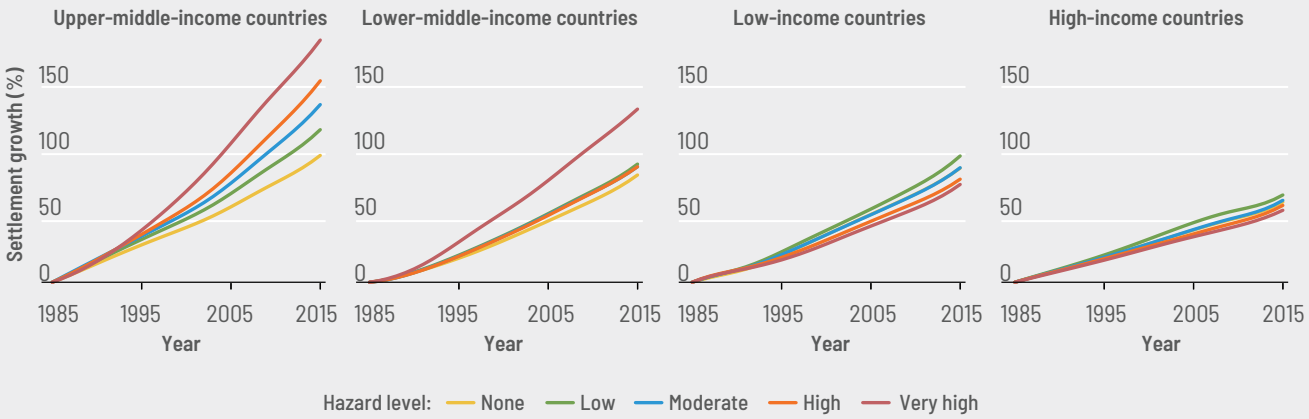


Source: World Bank staff calculations, using World Bank Group Scorecard data on percentage of people at high risk from climate-related hazards (https://scorecard.worldbank.org/); Hill et al. (forthcoming)

Without climate-informed policies and investment decisions, spatial development patterns often magnify exposure and risks. According to Rentschler et al. (2023), global urban growth in the most hazardous flood zones has been outpacing growth in safe zones (figure 12). This is particularly true in East Asia, where high-hazard settlements have expanded 60 percent faster than flood-safe ones. More generally, it is true in middle-income countries (MICs), where economies and cities have grown rapidly. The effects are most visible in UMICs, which have a higher proportion of settlements in the highest-hazard areas than any other group. Since 1985, these have grown by 184 percent, which is nearly twice the rate of flood-safe settlements (96 percent). LICs have seen more moderate settlement growth since 1985, and while most of it is on safe land, cities are still growing in flood zones: on average, settlements in high-hazard areas have grown 77 percent.

Without appropriate standards and incentives, new infrastructure will contribute to increased risk levels. By one estimate, LMIC governments are investing around $1 trillion—3.4–5 percent of GDP—in infrastructure every year (Fay et al. 2019); but most CCDRs conclude that countries'

FIGURE 12. EVOLUTION OF URBAN SETTLEMENT IN AREAS EXPOSED TO DIFFERENT RISK LEVELS, BY COUNTRY INCOME GROUP

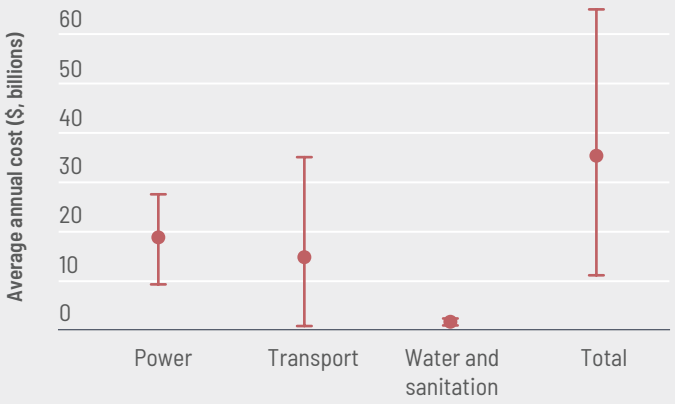


Source: Rentschler et al. 2023

design standards are outdated and not informed by climate risk estimates. Improving designs for the resilience of future power, water, sanitation, and transport infrastructure assets would cost LMICs $11–65 billion a year by 2030: an incremental cost of around 3 percent of overall investment needs (figure 13). While these additional costs are small, the net benefits of investing in more resilient infrastructure would be large, estimated at $4.2 trillion over the lifetime of the new assets, and producing $4 in benefits for each $1 invested (Hallegatte, Rentschler and Rozenberg 2019).

Reallocating public resources, especially distortive public subsidies, could also ensure a more resilient development pathway. Current subsidies in the energy, water, agriculture, or land sectors can incentivize excessive risk-taking or degrade natural areas and ecosystem services that provide resilience services (Damania et al. 2023). For example, energy subsidies and unpriced water can lead to excessive groundwater pumping that magnifies water scarcity and vulnerability to droughts. Reallocating these resources—notably toward payment-for-ecosystem services or resilience-

FIGURE 13. INCREMENTAL COST OF INCREASING THE RESILIENCE OF FUTURE INFRASTRUCTURE INVESTMENTS

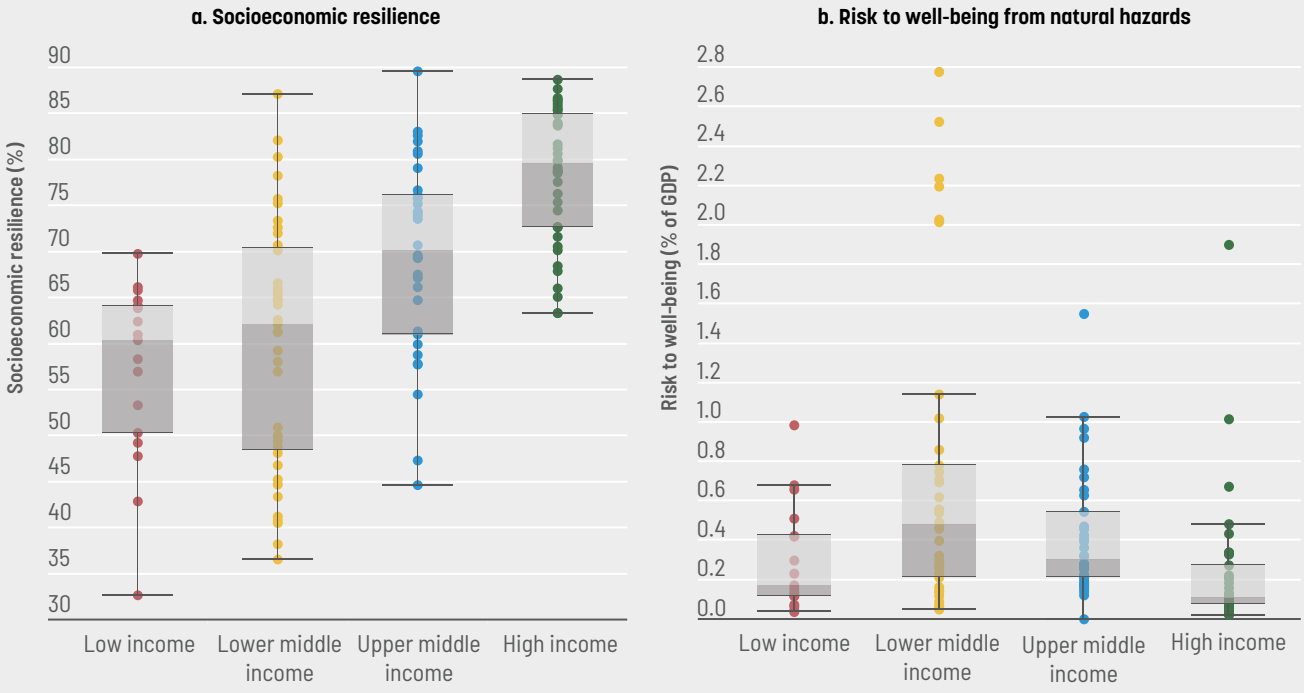


Source: Hallegatte, Rentschler and Rozenberg 2019

enhancing practices such as climate-smart agriculture—can provide the same level of support to beneficiaries while incentivizing more resilient choices. And in a time of constrained public resources, reallocating resources can provide much-needed funding for more resilient development.

Policy choices can make development more or less powerful in enhancing adaptive capacity and socioeconomic resilience, depending on the difference they make to inequality, financial inclusion, infrastructure development and quality, and social safety nets. As shown in figures 8a and 14a, there are large differences in vulnerability or resilience across countries at the same income level, particularly for MICs. While LICs tend to be very vulnerable and HICs rather resilient, some MICs follow development paths that deliver more resilience than others. Comparing countries at similar per capita income levels illustrates these differences: using the definition of high vulnerability from the World Bank's new risk indicator, 98 percent of Lao PDR's population has high physical vulnerability or low ability to cope (largely due to low social protection coverage), while in India, this number is much lower, at 23 percent, mostly due to better coverage in social protection and financial inclusion. China and Armenia also have similar per capita income levels, but China has much stronger resilience preparedness, driven by more established disaster risk strategies, the integration of climate risk considerations in sectoral policies, financial inclusion, and public budget commitments and financing for adaptation and disaster risk management (DRM).

FIGURE 14. SOCIOECONOMIC RESILIENCE AND WELL-BEING RISKS FROM NATURAL HAZARDS, BY COUNTRY INCOME GROUP



Source: World Bank staff calculations, based on Middelanis et al., forthcoming
Note: The box and whisker plot shows the interquartile range of the countries (dots) per income group in the shaded box, with the divide indicating the median value. The whiskers extend to 1.5 times the interquartile range per group. For visual simplicity, the figure excludes Haiti where risk to well-being is 5.8% of GDP.

1.1.3. Targeted adaptation interventions and climate risk management

Faster and better development, while necessary, are not enough to manage climate change and natural hazards; countries will also need targeted interventions and some retrofitting. Targeted risk management and climate change adaptation interventions will play a key role in reducing future impacts and losses, while retrofitting infrastructure or systems that have been designed for a different climate, or without properly considering natural hazards, will also be necessary. And because retrofitting existing assets is much more expensive than the incremental cost of building resilient assets in the first place, they can have extremely high financing and investment needs. Due to these high costs, the Brazil CCDR suggests that the benefit-cost ratio of road retrofit outside of the normal replacement schedule is below 1, although this is not the case for the most critical assets. Upgrading the main corridors for soy exports, which would cost around $400 million for benefits at $520 million, would have a benefit-cost ratio of 1.3 (World Bank Group 2023a).

One example of a targeted intervention is to upgrade river and coastal flood defenses in response to changing hydrology and sea level rise. For example, many major cities' flood protection systems designed with the assumption that sea level will remain stable will experience a rapid increase in flood risk level, making large investments in upgraded defense unavoidable (Hallegatte et al. 2013). Estimating the investment needs for improving river and coastal flood defenses, depending on the objective in terms of risk level. Rozenberg and Fay (2019) find that capital costs for river flood protection are an annual average of 0.04–0.47

Cars driving over the Tai Tam reservoir in Hong Kong. Credit: © Chunyip Wong/istock.com

▲
Luísa brought one of her children for a check-up in Djodjo, Mozambique. Credit: © UNCDF/Souza Domingos 2024

percent of LMIC GDP for the least expensive strategy, while maintaining the current absolute level of risk would cost 0.15–2.4 percent. For coastal protection, future investment needs also span a wide range (0.006–0.19 percent of GDP per year, on average) depending on construction costs and the protection strategy pursued. Although they appear low, this is partly because the costs of very localized and partial protections are being spread over national GDPs.

Resilience investments can yield significant economic gains and other co-benefits. DRM interventions in urban areas, such as flood mitigation, can increase the value of the land, creating opportunities to recoup some of the flood protection costs. This can be achieved through land taxation, development or impact charges, or incentives for private landowners to agree to provide in-kind flood-protective infrastructure, creating fiscal space for governments. A study in Argentina found that, even with conservative assumptions, a citywide land value appreciation from flood management investments in Buenos Aires could range from $380 million to $2 billion dollars, above the estimated cost of $338 million dollars (Avner et al. 2022). Similarly, flood-protective measures in the lowlands near Dar Es Salaam's Central Business District could unlock up to $900 million in real estate investments, including the construction of up to 5,900 new housing units, and generate $200 million in land-related revenue, which the city could recoup by selling land and development rights to private investors.[11]

1.1.4. Resilience, or just good development?

The balance between faster development, better development, and targeted

[11] https://blogs.worldbank.org/en/sustainablecities/turning-flood-risk-economic-opportunity-dar-es-salaam-tanzania.

interventions will depend on context. In HICs, where people have universal access to basic social, financial, and infrastructure services, the focus will naturally be toward targeted interventions to adapt existing systems and infrastructure to a different climate. But in LICs, where most of these systems still need to be built, and will be built in the next decades, the broader development agenda will play a much bigger role. Because it is much cheaper to build resilient assets in the first place than to retrofit assets for enhanced resilience, LICs have an opportunity to achieve resilience at a lower cost than richer countries.

Better development and targeted adaptation interventions will enable faster development. This is evidenced by the impact that unmitigated disasters impose on growth and development. After Ethiopia's 1984–85 famine, it took a decade, on average, for asset-poor households to bring livestock holdings back to pre-famine levels (Dercon 2004). Disasters can also keep people in poverty, because when household assets go below a certain critical value, it can become difficult or almost impossible to rebuild the asset stock (Carter and Barrett 2006; Carter et al. 2007). Long-term impacts on human capital, through impacts on health and education, are also well documented. In Sub-Saharan Africa, asset-poor households respond to weather shocks by reducing the quality of the nutrition they give their children, with long-term implications for their economic prospects and opportunities (Dercon and Porter 2014; Yamano, Alderman and Christiaensen 2005).

Improved resilience can enhance long-term development through people's investment behaviors—a benefit referred to as the "second dividend" of resilience. When people do not have the proper tools to manage natural risk, they cannot afford to take any other risks, which reduces their ability to invest in businesses or assets. They also tend to spread risk over multiple lower-risk activities and reduce their investments, thereby reducing any returns on those investments. Disaster risk reduction can therefore generate growth and benefits, beyond avoided losses, by promoting more investment. The *Triple Dividend* reports refer to this benefit as the "second dividend of disaster risk reduction" (Tanner et al. 2015; Heubaum et al. 2022); the first is that disaster losses can be avoided, and the third refers to co-benefits, such as when a water retention area can also be used as a recreation park or a dike is combined with a road.

1.2. Financial needs for development and adaptation are strongly interlinked

An important implication is that it is impossible to separate investment needs for development from A&R investment needs. The interlinkage between development and resilience investments is obvious in the CCDRs, which identify investment needs for resilient low-emission development, and do not separate these needs between development and resilience. In a subset of 44 economies, climate-development financing needs are larger as a percentage of GDP in poorer countries, totaling 1.1 percent of GDP, on average, in UMICs, 4.4 percent in LMICs, and as much as 8 percent in LICs (figure 15).

The need to close development gaps to make populations more resilient explains why investment needs are so much higher in lower-income countries. The Pakistan CCDR includes universal access to improved water and sanitation by 2030 as an investment need for resilience, representing $55 billion out of a total of $348 billion (World Bank Group 2022d). While providing populations with improved water and sanitation is a development objective, the

FIGURE 15. INVESTMENT NEEDS FOR RESILIENT LOW-EMISSION DEVELOPMENT IN CCDR COUNTRIES

Source: World Bank Group 2024

report identified it as a priority for resilience that contributes to the country's high investment needs. Similar urgent development needs that have large resilience co-benefits explain the high investment needs identified in other CCDRs, such as in the Sahelian countries or Cameroon (World Bank Group 2022b, 2022c).

Climate finance estimates do not capture the full range of A&R investments, especially when resilience is embedded in other public and private investments. Estimates of adaptation-related investment needs usually include the incremental cost of building more resilient infrastructure or basic infrastructure services (UNEP 2023; CPI 2023; World Bank Group 2023d, 2024), but these are not captured in estimates of adaptation finance (CPI 2023). This partly explains why only 5 percent of total climate finance ($63 billion per year in 2021–22) is invested in adaptation. The difference in scope between measures of adaptation finance and

estimates of A&R investment needs makes it difficult to calculate a precise investment gap.[12] Collecting data on a broader range of adaptation investments—including the incremental costs of resilience embedded in private investments—would be extremely challenging and resource-intensive.[13]

LMIC adaptation and development finance needs are much greater than existing international public finance flows and available private finance. Global climate finance estimates suggest that the adaptation finance gap is growing, with LMIC adaptation costs projected at $212–387 billion per year in this decade (UNEP 2023; CPI 2024; Buchner et al. 2023). But this is compounded by a broader gap in accessing finance in general. Current high levels of public debt make it more difficult for LMICs to access financing to provide populations and economies with the infrastructure and services they need for growth and development. And high real and perceived risks, such as those related to foreign exchange or policy uncertainty, increase the cost of capital for public and private actors, making even high-return development and adaptation investments unviable.

1.3. The private sector has a crucial role to play, but faces many barriers

Private firms will invest in adaptation when and where it is relevant to their continued profitability and market position. Adaptation presents risks as well as opportunities for firms and businesses. A growing number of insurers, banks, and companies recognize the risks of inaction, but also the opportunities in adaptation and resilience. For instance, analysts at Bank of America project a $2 trillion market for climate adaptation within the next five years,[14] while J.P. Morgan Asset Management notes that investing in climate-resilient projects can offer higher returns—for example, on real estate portfolios (Wu et al. 2023).

The business rationale for proactive A&R investment is clear. The business case for adaptation is central to the UN High-Level Champions *Business Action for Adaptation & Resilience* paper, which focuses on integrating climate risks into business strategies and how companies can capitalize on emerging opportunities and meet stakeholder expectations (PwC et al. 2024), while others identify key opportunities for private sector investment in emerging markets (Chau et al. 2023). A United Nations Framework Convention on Climate Change database reveals that private sector adaptation initiatives in LMICs often emphasize social development and frequently involve nongovernmental organizations (NGOs) and development banks.[15] In contrast, initiatives in HICs typically concentrate on business opportunities in climate-sensitive sectors or enhancing companies' infrastructure, value, or supply chains. For example, one report

[12] Unlike the clear targets set for global GHG emissions, estimating adaptation finance needs is complicated, due to various factors such as the lack of universally agreed quantitative objectives, and the desired level of resilience is a political decision with no correct answer. For example, countries or cities with similar income levels may have vastly different flood protection measures, and investment needs depend on community risk tolerance, as well as political and technical decisions, such as whether to protect existing assets or retreat from vulnerable areas.

[13] For private adaptation, finance is likely significantly higher than reported. The Climate Policy Initiative recently increased its estimate of annual average tracked private adaptation finance for 2019–22 from $1 billion to $4.7 billion, based on a new methodological approach using machine learning (CPI 2024).

[14] https://www.bloomberg.com/news/articles/2021-11-17/why-investing-in-climate-adaptation-will-soon-be-very-profitable-green-insight.

[15] https://unfccc.int/topics/resilience/resources/psi-database.

showcases the profitability of adaptation and importance of corporate leadership in driving resilience (Bailey et al. 2024); another highlights the need for businesses to integrate resilience into their strategies to drive innovation and mitigate risks (WEF and PwC 2023).

While all private sector actors have an incentive to adapt—to reduce costs and improve performance—they also face market failure and other obstacles. Despite growing awareness and investments, businesses face significant information, regulatory, market, and coordination challenges when responding to climate risks. Key barriers include:

- **Coordination failure, climate uncertainties, information asymmetries, and knowledge gaps**: A lack of coordination between actors—including other businesses in the same sector, firms' supply chains, and the public sector—can hamper collective A&R efforts. Uncertainties in climate models also complicate risk assessments and the identification of adaptation options and their economic returns. Investors often have limited access to information on climate impacts, future risks, and likely adaptation outcomes,[16] so verifying the effectiveness of emerging approaches in delivering potential environmental and social benefits can be both difficult and costly.
- **Difficulties in monetizing resilience benefits and accessing finance:** The lack of detailed data linking interventions to business-relevant A&R outcomes (particularly in the short term) makes it difficult for firms to calculate returns on investment and make informed investment decisions. Having access to longer-term finance, consistent with the risk-return profile and time horizon of adaptation-related cashflows, can facilitate private sector investment.
- **Limited awareness**: The lack of awareness in the private sector about opportunities to invest in resilience is partly due to the lingering perception that adaptation and resilience are primarily responsibilities of government rather than a viable area for private investment. To capitalize on emerging opportunities as climate impacts increasingly affect businesses and supply chains, the private sector will need to recognize that resilience is a critical investment area.
- **Unclear definitions and metrics**: The absence of clear and standardized definitions for climate resilience solutions creates confusion among investors and issuers, making it difficult to identify and invest in impactful projects. The overlap between adaptation activities and developmental efforts also complicates the tracking and monitoring of progress, further challenging companies' ability to gauge the effectiveness of A&R investments.
- **Credit vulnerabilities**: Even when resilience investments have a clear economic rationale and monetary benefits—for example, when upfront resilience investments will reduce lifelong maintenance and operational costs—they tend to be implemented by public or private entities, including state-owned enterprises, that are often financially fragile. The project proponent's real or perceived high credit risk can constrain borrowing.

These barriers disproportionately affect small businesses and informal firms. Typically, large businesses find it easier to access resources and implement adaptive measures, while micro, small, and medium-sized enterprises

[16] https://www.wri.org/insights/patchy-guidance-companies-may-have-climate-risk-blind-spots.

lack capacity and need support through shared climate data, adaptation knowledge, financing mechanisms, and collaborative initiatives. Notably, business environment constraints—such as limited access to finance or streamlined business regulation—disproportionately affect young and small firms, raising the cost of investing in adaptation measures or technologies. In Japan, small and medium-sized enterprises (SMEs) have adopted stronger supply chain resilience measures, such as business continuity plans, in response to incentives and requirements, such as preferential interest rates on loans, discounted insurance premiums, or requests from parent companies or customers (World Bank 2020b).

Several reports provide frameworks that emphasize the need for long-term planning and public-private partnerships (PPPs). The International Finance Corporation and World Bank both highlight strategic interventions to create favorable conditions for investment (Stenek, Amado and Greenall 2013; Tall et al. 2021), while the United States Agency for International Development focuses on building effective partnerships and developing financial tools and incentives to foster private sector investment in resilience (Maor, Gallagher and Dugard 2023). The Asian Development Bank outlines five pillars—including policy dialogue, new financing tools, and nature-based solutions (NbS)—to enhance private engagement (Lu 2022).

A supportive business environment with collaboration between businesses, governments, and communities is essential for effective adaptation. Given the many

Man standing in boat on river within the forest in Thiruvananthapuram, India. Credit: © EyeEm Mobile GmbH/istock.com

complementarities between firm adaptation, public sector adaptation, and public goods provision, governments still play a crucial role in providing the necessary enabling environment (Rexer and Sharma 2024) and can lead a coordinated public-private approach to ensure long-term resilience (UN Global Compact et al. 2015; WBSCD 2024).

1.4. Advancing A&R goals requires a whole-of-society response

Urgent needs for scaling up climate risk management and A&R preparedness require a whole-of-government and whole-of-society response. Although countries have taken measures and made some progress in addressing climate and disaster risks, this is uneven across countries and policy areas (World Bank Group 2023d). Adaptation policy and implementation remain fragmented, local, and incremental, and there is limited evidence of transformational adaptation and risk reductions (Berrang-Ford et al. 2021).

Both the public and private sectors have a role to play in implementing A&R responses. To facilitate private A&R action, the public sector can establish an enabling policy environment, manage macroeconomic and fiscal stability, set clear targets, roles, and responsibilities, and produce and disseminate climate information. It can also define land use and zoning requirements, set infrastructure standards, invest in research, development, and technologies that generate public benefits, address market failures by removing harmful

African woman working corn field in rural town, Malealea, Lesotho. Credit: © wilpunt/istock.com

subsidies, and deploy financial instruments such as budget allocation or de-risking mechanisms.

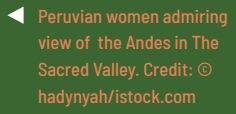
To achieve required scale, A&R responses need to be multisectoral, multiscale, and coordinated across governance levels—between central and line ministries and from national to local levels. A whole-of-government approach is needed to closely coordinate and integrate A&R priorities in national economic and sectoral development policies, streamlining existing policy and institutional frameworks or establishing new ones as required (Hallegatte, Rentschler and Rozenberg 2020). Developing and implementing A&R objectives needs support, buy-in, and commitment from the highest level of government and central ministries, including finance, economy, and planning. And because climate impacts cascade across sector and geographic boundaries, any interconnections and trade-offs need to be managed deliberatively. For instance, an agriculture adaptation strategy to enhance the irrigation of current agricultural production in response to drought can lead to maladaptation in an already water-stressed country, so coordination between the ministries of agriculture and water is crucial.

Strong, inclusive, local-level participation in implementing A&R action is necessary to ensure locally appropriate solutions, ownership, and agency, and to build the resilience of people and communities. Climate vulnerability and impacts manifest differently depending on physical exposure, socioeconomic characteristics, and the capacity of local institutions. Effective A&R strategies and implementation need to consider vulnerability, sociocultural contexts, and local community priorities, and effective climate change-informed development policies, and involve multisectoral integration and well-coordinated institutions at all levels of government to ensure that the gains of development reach the most vulnerable populations and are resilient to climate change impacts.

To assess how much such a whole-of-society approach is implemented in countries, the next chapter presents results from an A&R readiness assessment applied to 44 countries and economies. It confirms that, while there is progress on climate change adaptation, most countries are far from having fully mainstreamed climate risks and adaptation needs in their economic and development plans and policies.

CHAPTER 2

More is needed: gaps and priorities identified by country A&R readiness assessments



◀ Peruvian women admiring view of the Andes in The Sacred Valley. Credit: © hadynyah/istock.com

The A&R readiness assessment[17] provides a whole-of-government, whole-of-economy assessment of countries' A&R policy, institutions, capacity preparedness, and implementation. The framework is organized along six pillars: building resilient foundations through rapid and inclusive development; facilitating the adaptation of people and firms; adapting land use and protecting critical public assets and services; increasing people's and firms' capacity to cope with and recover from shocks; anticipating and managing macroeconomic and fiscal risks; and ensuring effective implementation with a robust governance structure and continuous monitoring (figure 16). Each pillar has a set of priority actions corresponding to policy domains and key aspects of the enabling environment required for effective adaptation, and these are evaluated based on a set of indicators.[18]

The assessment helps identify gaps in countries' preparedness and provides a framework to monitor and evaluate progress against predetermined objectives. Its flexible and consistent framework reflects country A&R priorities and can be used to evaluate a country's progress in A&R actions and capacity development, identify gaps, and support the design of effective A&R policies and strategies.

[17] The assessment follows the approach developed in the World Bank's Adaptation Principles (Hallegatte, Rentschler and Rozenberg 2020), a framework that reflects universal principles for effective climate change adaptation and building resilience that are relevant for all countries.

[18] A mix of quantitative and qualitative indicators are assessed and assigned a score of 1, 2 or 3 according to the rating criteria using a range of information sources and methods, including benchmarking against peer countries and expert judgment. See the appendix for more information on the assessment methodology.

FIGURE 16. THE ADAPTATION PRINCIPLES FRAMEWORK

A&R readiness assessments, carried out for 44 countries,[19] have been used as inputs to the CCDRs. CCDRs aim to help countries prioritize the most impactful actions to boost resilience and adaptation to climate change and reduce GHG emissions while delivering on broader development objectives.[20] By providing a whole-of-economy assessment of a country's A&R preparedness, the readiness assessment provides important information on progress and gaps that CCDRs use to develop concrete actions and recommendations for strengthening adaptation and resilience. The assessments represent countries in different regions, with different income levels, and at varying stages of development (table 2). They face different climate risks and vulnerabilities due to geography, exposure of population, infrastructure and economic activity. And they have different capacities to withstand and respond to the changing climate conditions. Box 2 shows an application of the A&R assessment in Côte d'Ivoire. Over time, the A&R readiness assessment can also be used as a monitoring tool to evaluate and track a country's progress toward enhancing adaptive capacity and preparedness.

2.1. Key gaps and priorities for action

Using a consistent framework, the 44 A&R readiness assessments suggest that A&R preparedness varies across domains and sectors, both within and between countries. Figure 17 presents the aggregate assessment results along the six pillars across the 44 countries (a) and by country (b). These analyses confirm that development gaps, poverty, inequalities, and macroeconomic instabilities are key constraints on adaptation and resilience. Richer, more economically stable countries are better able to respond to shocks, anticipate future risks and stresses, and invest in adaptation and resilience. And people in richer countries with lower inequality and more

[19] The country selection is based on the completion of A&R readiness assessments as a key input to CCDRs, and results from a World Bank regional report for the Caribbean (Browne et al. 2021). They include two economies—Sint Maarten and Turks and Caicos Islands—but for brevity, these are referred to as countries in this report.

[20] https://www.worldbank.org/en/publication/country-climate-development-reports.

TABLE 2. A&R READINESS ASSESSMENT: THE 44 COUNTRIES INCLUDED IN THE REPORT

REGION	LMICS	UMICS		HICS
East Asia & Pacific	Cambodia	China		
Europe & Central Asia	Tajikistan Uzbekistan	Albania Armenia Azerbaijan Bosnia and Herzegovina Kosovo	Moldova Montenegro North Macedonia Serbia Türkiye	Austria Poland
Latin America & Caribbean	Haiti	Belize Colombia Dominica Dominican Republic Ecuador Grenada	Jamaica Peru St. Lucia St. Vincent and the Grenadines Suriname	Antigua and Barbuda Bahamas, The Barbados Guyana Sint Maarten (Dutch part) St. Kitts and Nevis Trinidad and Tobago Turks and Caicos Islands
South Asia	Bhutan India			
Sub-Saharan Africa	Cabo Verde Côte d'Ivoire Guinea Senegal Togo Uganda			

BOX 2

A&R readiness assessment to inform Côte d'Ivoire's national adaptation plan (NAP) development

An A&R readiness assessment was carried out as part of the Côte d'Ivoire CCDR. A vulnerable West African country, Côte d'Ivoire faces significant challenges, including rising temperatures, more extreme weather, higher flood and drought risks, and up to 30 centimeters of sea level rise by 2050 (World Bank Group 2023c). Climate change could result in 2–3.5 million people living below the poverty line by 2050, with losses borne in agriculture, infrastructure, and human development, including key economic sectors such as cocoa and energy. Based on an assessment of 179 indicators, the main recommendations of the A&R readiness assessment focus on the need to strengthen interministerial coordination and alignment mechanisms on climate change at the central level.

Active collaboration with counterparts in Côte d'Ivoire was crucial during the CCDR consultation process. The assessment was presented to government counterparts and stakeholders on three occasions, who provided valuable feedback and comments as well as information to complement the World Bank team's desk analysis. The timing of the CCDR also coincided with the development of Côte d'Ivoire's first NAP, and the active dialogue and information exchange benefited both parties.

The Côte d'Ivoire CCDR is now in its implementation phase. The tool was handed over to the government in an effort to operationalize the A&R assessment and support the implementation of the Côte d'Ivoire NAP by establishing a baseline to track progress over time.

FIGURE 17. A&R READINESS ASSESSMENT RESULTS ACROSS 44 COUNTRIES

Source: World Bank staff calculations, based on World Bank A&R country readiness assessments
Note: Each indicator is assigned a score of 1 (nascent), 2 (emerging), or 3 (established) using a range of information sources and methods, including benchmarking against peer countries and expert judgment, and then aggregated with equal weight for each priority area and pillar. In panel a, each dot represents a country's average score in the corresponding pillar, with the mean represented by a cross and scores between the 25th and 75th percentiles represented in the shaded box.

inclusive growth tend to be better equipped to anticipate, adapt to, and cope with climate impacts.

Beyond development gaps, the A&R readiness assessments highlight three other gaps in most countries.

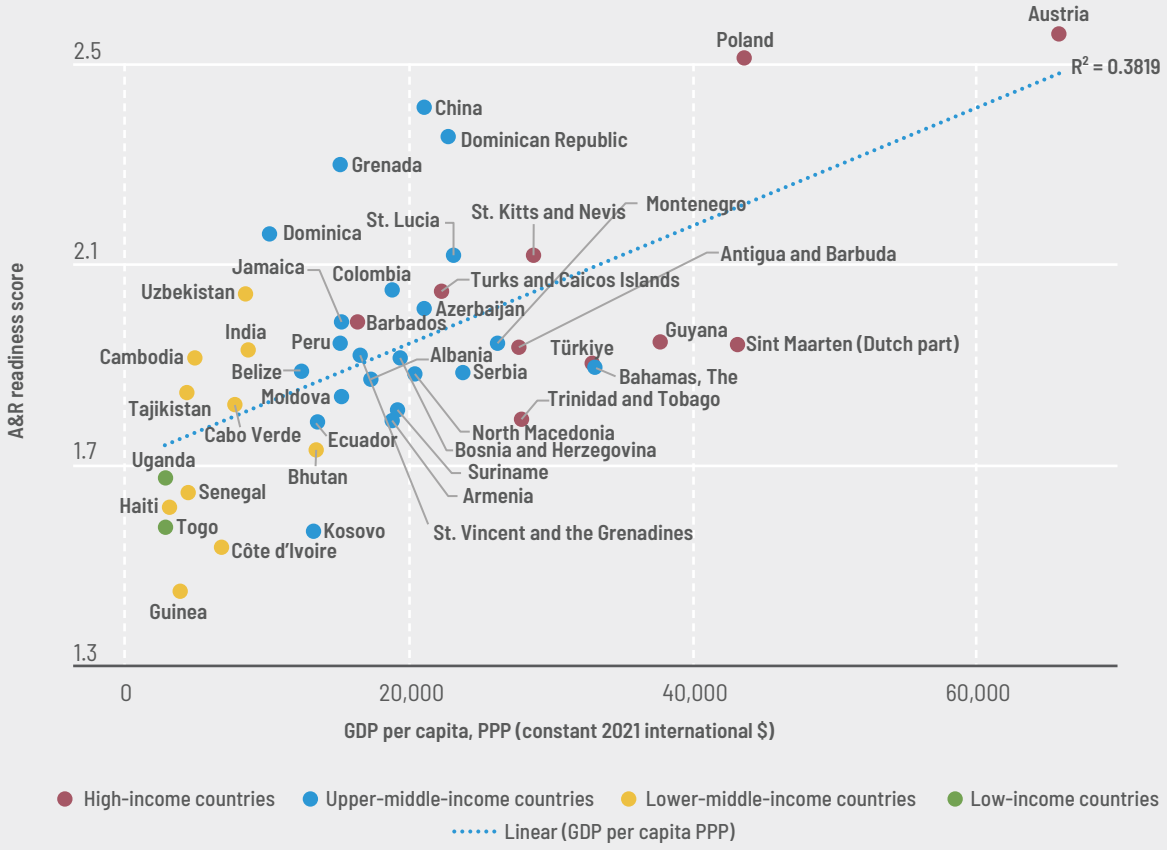
1. **While countries have made notable progress in developing strategies and institutional arrangements for resilience and adaptation, large implementation gaps remain at sector level.** On average, countries perform better on indicators related to plans and strategies than on effective action and investment at sector level. This is particularly so when it comes to land use, basic infrastructure, and social services.
2. **Countries are showing the least progress in addressing macrofiscal issues.** This gap highlights the technical and capacity challenges in identifying, quantifying, and managing macrofiscal risks posed by climate impacts, including risks to macroeconomic stability, public finances, debt sustainability, and the financial sector.
3. **More proactive action is needed, as reactive adaptation response and recovery still tend to be the norm in many countries and can be economically and socially costly.** At sector level, health system resilience readiness is highest, on average (possibly a positive outcome of the COVID-19 pandemic). Caribbean UMICs and HICs, which face relatively high exposure to climate change, demonstrate stronger national frameworks and climate disaster management preparedness than their less-exposed peers.

2.2. Foundations: rapid, robust, and inclusive development to build resilience

Stable macroeconomic growth, poverty reduction, access to basic services, and social inclusion lay the foundations for climate change adaptation and provide buffers against climate shocks. The assessments confirm that, overall, country adaptation performance is strongly correlated with economic development (figure 18). Austria, Poland, the Dominican Republic, and China—all HICs and UMICs—exhibit

Tamil pickers collecting tea leaves in Southern India. Credit: © hadynyah/ istock.com

FIGURE 18. GDP PER CAPITA AND OVERALL A&R SCORE



Source: World Bank staff calculations, based on World Development Indicators and World Bank country A&R readiness assessments

stronger A&R readiness, while preparedness is lowest in lower-income countries, which have high poverty rates, low access to basic services including electricity, safe drinking water and sanitation, education, and limited financial services and social protection.

Inclusive development policies and access to basic services provide crucial buffers against climate shocks. Low access to basic services such as health care, telecommunications, safe water, and sanitation, coupled with a high degree of informality, especially in rural areas, increase the population's vulnerability and decrease their socioeconomic resilience. In Uganda, Guinea, and Haiti, less than half the total population has access to electricity, a vital service on coping with heatwaves and for general well-being. Access to basic sanitation services is an even larger struggle for these countries, along with Togo and Côte d'Ivoire, where less than half the total population has access.

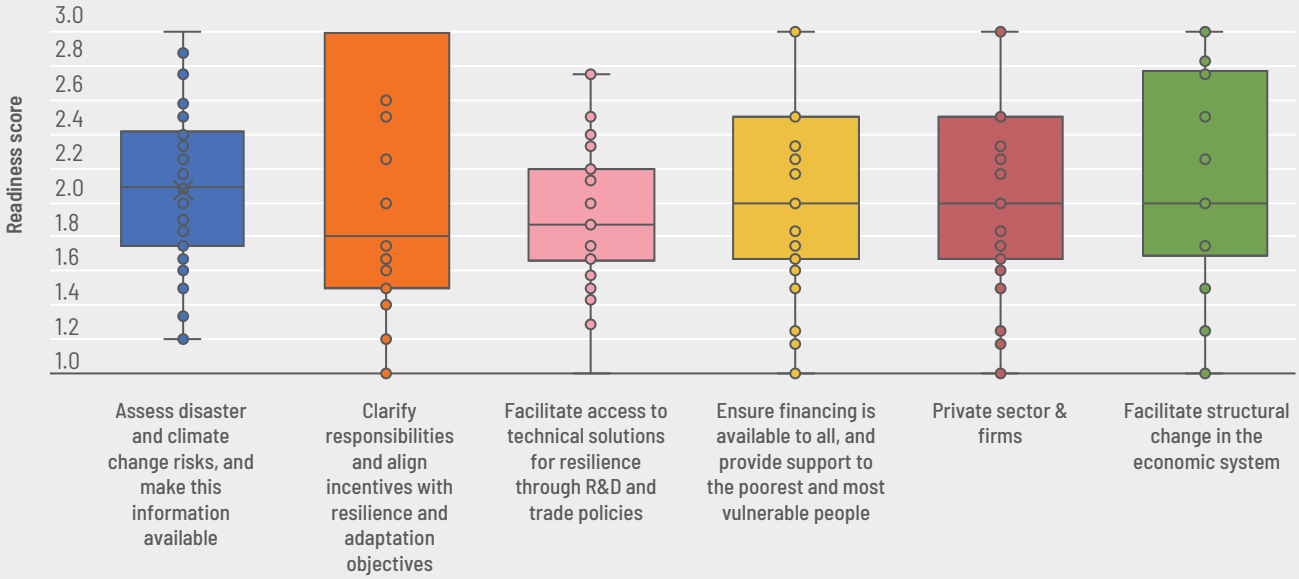
2.3. Priority Area 1. Facilitate the adaptation of people and firms

People and firms have an incentive to adapt to future climate change, but they face significant information, regulatory, market, financial, and behavior barriers that governments can

help address. Governments can maximize their economy's and society's adaptive capacity while minimizing the impacts of climate change and natural hazards by reducing barriers for private actors to adapt to climate change. In general, countries have made progress in providing the public access to climate and disaster risk information, but there is room for improvement around clarity and coordination of adaptation responsibilities and aligning incentives with adaptation goals. While many countries have established responsibilities for climate adaptation and DRM in law, a significant implementation and financing gap remains, with inadequate delegation and coordination of roles and responsibilities (figure 19).

One key area for improvement lies in aligning incentives and clarifying private actor roles and responsibilities for adaptation and resilience. Most countries have not established or clearly communicated acceptable residual risk target levels. With decades of flood risk management experience, the Netherlands has publicly available levels of residual flood risks, accounting for the protection offered by public infrastructure. Tajikistan is one of the few countries with a target for residual risk: its Green Economy Development Strategy for 2023–37 provides milestones and a matrix of measures for each priority area and commits to gradually reduce the share of damage from disasters from 4 percent of GDP (baseline level) in 2021 to 3 and 2 percent by 2027 and 2037, respectively. Another example is Dominica. After Hurricane Maria devastated the country in 2017, the newly established Climate Resilience Execution Agency for Dominica set clear objectives and measurable targets to enhance resilience in the small island country.

FIGURE 19. AVERAGE SCORE FOR EACH ACTION AREA WITHIN PRIORITY AREA 1: FACILITATE THE ADAPTATION OF PEOPLE AND FIRMS



Source: World Bank staff calculations, based on World Bank country A&R readiness assessments
Note: Each indicator is assigned a score of 1 (nascent), 2 (emerging), or 3 (established) using a range of information sources and methods, including benchmarking against peer countries and expert judgment, and then aggregated with equal weight for each priority area and pillar. Each dot represents a country's average score in the corresponding pillar, with the mean represented by a cross and scores between the 25th and 75th percentiles represented in the shaded box.

As illustrated in detail in chapter 3 of this report, private sector A&R actions are emerging, but major gaps remain. Globally, only one in five companies has a climate adaptation plan, and less than half of those have started to implement their plans (S&P Global 2023). This is confirmed in various country A&R assessments, which include firm surveys. For example, very few firms in Azerbaijan and Uzbekistan have developed frameworks or implementation capacity for climate change adaptation and business continuity plans in their operations. However, as shown in chapter 3, A&R action is emerging in the private sector and in countries with robust markets and trade integration, where many companies committed to sustainability and disclosures are more likely to invest in adaptation and resilience.

Climate risk data and information are needed, especially at a more granular scale, for community and local decision-making. Most countries have developed hydrometeorological (hydromet) capability and carried out climate risk and vulnerability assessments for key sectors. But the coverage and availability of high-resolution data, detailed hazard maps, and local-scale climate change scenarios need to be improved and made publicly available. In Uzbekistan and Azerbaijan, the lack of real-time monitoring and limited manpower undermine the effectiveness of the current impact-based forecasting system. In some small countries, such as St. Kitts and Nevis, Kosovo, and Guinea, the lack of climate information and services makes it difficult for farmers and natural resource-dependent workers to prepare for weather extremes and other impacts of climate change. As illustrated in section 3.2.1, Bangladesh is making progress in providing end-to-end services that can support farmers to build resilience and reduce casualties in disaster events, but such services are far from universally available.

Firms and people need access to digital technologies, which are a key enabler for climate response and resilience building. Digital technologies support climate risk assessment and analysis, remote sensing, early warnings, real-time data dissemination, public services, and social protection payments. Digital development can also enhance governance and climate response by improving transparency, accountability, and stakeholder engagement. But nearly three billion people globally, mostly in LICs and MICs, lack digital connectivity. The digital divide hinders resilience opportunities for the most vulnerable.[21] The Telecommunications Infrastructure Index[22] highlights that countries—including Uganda, Haiti, Togo, and Guinea—have much room for improvement, while some high-income Small Island Developing States (SIDS), such as The Bahamas and St. Kitts and Nevis, perform relatively well. Meanwhile, digital infrastructure may be susceptible to extreme climate events, such as storms, floods, extreme heat, and sea level rise, so it is important for digital project development to undertake climate risk assessments and incorporate climate-resilient design and measures to deliver intended benefits.

[21] World Bank Climate Change and Digital Development (CCDD) data dashboard. https://spatialagent.org/CCDD/.

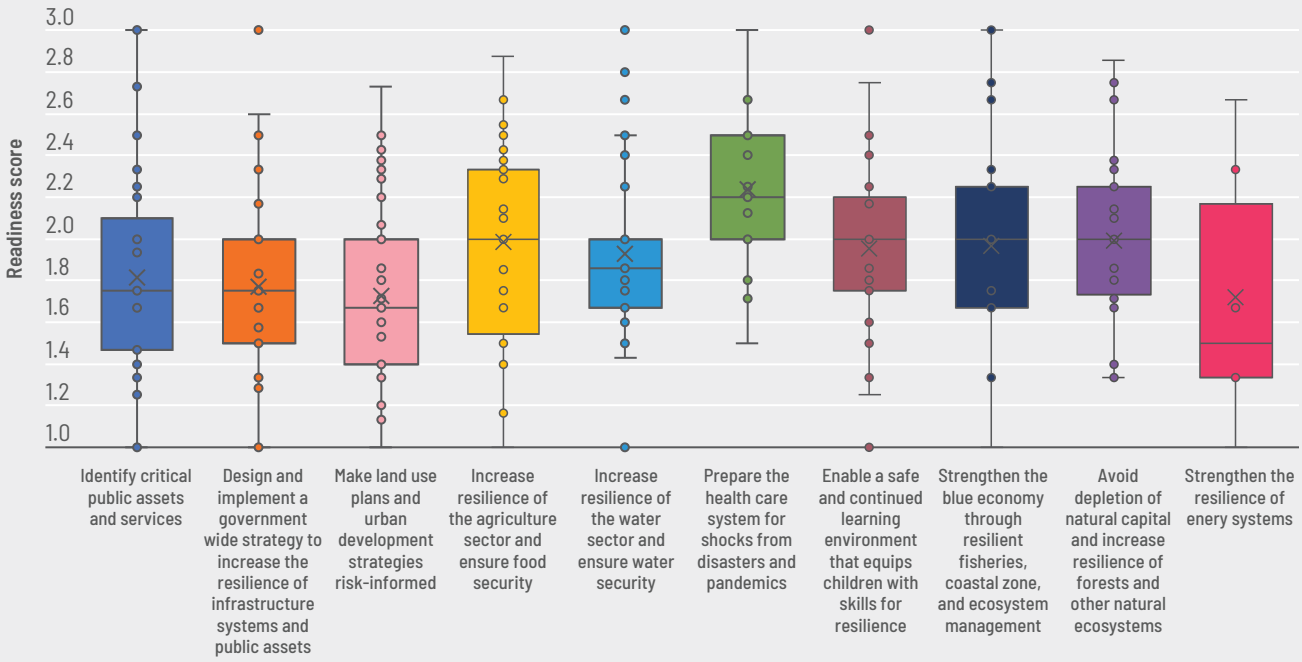
[22] A measure of telecommunication connectedness, this index is an arithmetic average of five indicators: estimated internet users, and number of main fixed telephone lines, mobile subscribers, wireless broadband subscriptions, and fixed broadband subscriptions per 100 inhabitants (https://publicadministration.un.org/egovkb/en-us/About/Overview/-E-Government-Development-Index; https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2016-Survey/Annexes.pdf).

2.4. Priority Area 2. Adapt land use plans and protect critical public assets and services

Governments have a transformative role to play in ensuring the adaptation and resilience of critical public assets and infrastructure systems, land use plans, and natural environments (land, air, and oceans). Countries perform relatively well, on average, in preparing their health care systems for shocks and pandemics, possibly due to lessons learnt and recovery experiences in the aftermath of the COVID-19 pandemic. But they lag in strengthening the resilience of energy systems, public assets, and infrastructure, making land use and urban plans risk-informed, and increasing water security.

Many countries lack the adequate institutional framework, technical capacity, and finance to integrate climate resilience in urban and land use planning. Many Caribbean SIDS, including Jamaica, Haiti, and the Dominican Republic, have some legislative framework for urban and land use planning but face implementation challenges for climate risk assessments in urban areas. Considering the pace at which many countries are urbanizing, including in flood zones, and the fact that urbanization in high-risk areas is hard or even impossible to reverse in the future, the lag in adjusting land-use plans to future climate risks is particularly problematic, and likely to become a source of major expense. Assessment results for this priority area across countries are presented in figure 20.

FIGURE 20. AVERAGE SCORE FOR EACH ACTION AREA WITHIN PRIORITY 2: ADAPT LAND USE PLANS AND PROTECT CRITICAL PUBLIC ASSETS AND SERVICES



Source: World Bank staff calculations, based on World Bank country A&R readiness assessments
Note: Each indicator is assigned a score of 1 (nascent), 2 (emerging), or 3 (established) using a range of information sources and methods, including benchmarking against peer countries and expert judgment, and then aggregated with equal weight for each priority area and pillar. Each dot represents a country's average score in the corresponding action area, with the mean represented by a cross and scores between the 25th and 75th percentiles represented in the shaded box.

▲ Aerial view of the barrier reef in the island of Ambergris Caye Belize. Credit: © Oli Eva/ istock.com

Most countries have major gaps in meeting infrastructure resilience investment needs, and lack asset management systems, climate risk screening, inventory of critical public assets, and budget for boosting infrastructure resilience. Strengthening the resilience of critical energy, water, and transport systems should be an adaptation priority, given the importance of such services for resilience and development. But few countries have risk-informed asset management systems, and the lack of maintenance is often identified as a key reason why infrastructure assets are not resilient to extreme weather events. The case study on a regional resilient infrastructure system program in the Pacific islands (section 3.2.2) shows how countries are making progress in increasing the resilience of their transport systems, with more risk- and condition-informed maintenance and design; the First Water Cisterns (FWC) case study from Brazil (section 3.2.3) illustrates a program that is building infrastructure with the explicit goal of improving resilience, with notable and measurable results. Development of accessible and robust resilience assessment frameworks and tools also help support and inform resilient infrastructure planning and design (box 3).

Biodiversity and natural ecosystems, such as forests and oceans, play an important role in protecting people and livelihoods from climate risks. Land use change, urbanization, unsustainable agricultural and fishing practices, and climate change all contribute to biodiversity loss. Many countries also face political, institutional, and financial challenges to manage natural resources and increase the resilience of terrestrial and aquatic ecosystems, and need to step up ecosystem conservation, management, and adaptation to climate change with a landscape and cross-sectoral approach. NbS—including afforestation, forest management, and nutrient management—offer opportunities to contribute to climate change mitigation and resilience while promoting biodiversity (box 4). For example, China's National Climate Change Adaptation Strategy 2035 notably emphasizes NbS as one of its guiding principles and includes afforestation and ecosystem restoration measures. In many tourism-dependent SIDS, marine habitats are protected (for example, protected habitats cover 7 percent of Cabo Verde's national marine space), yet enforcement remains a challenge.

BOX 3

Tools and frameworks to make infrastructure more resilient

One key challenge is ensuring that all new infrastructure assets and systems are built to the appropriate resilience standards, based on present and future climate risks and accounting for the uncertainty in how risks will evolve in the future. Many methodologies exist but are often data- and model-intensive and therefore difficult to deploy operationally. The examples below are recent methodology developments that try to find the balance between implementation costs, feasibility, and the risks of overly simplified approaches, which can lead to inappropriate designs.

Resilience Rating System (RRS) and Climate Risk Stress Test (RiST): To guide investment decisions and improve climate resilience in project design and outcomes, the World Bank Group developed the RRS (World Bank Group 2021c), which evaluates and rates investment projects from C to A+, based on their resilience attributes in two complementary dimensions. The *resilience of* rating considers a project's design, reflecting the confidence that it will achieve its expected objectives and maximize development benefits in the face of climate and disaster risks. The *resilience through* rating considers a project's outcomes, reflecting its contribution to improving climate resilience in the broader community, sector, and systems, and driving transformational adaptation. A pilot of the RRS in a wide range of activities and countries shows that it provides a robust, yet simple and flexible, framework to evaluate and integrate climate risk management and resilience measures in projects (World Bank 2024d). It can be used as a rating or label to monitor and track the quality of A&R performance in a project, or a reporting tool to monitor the overall resilience performance of portfolios. To ensure the economic viability of a project against current and future climate and disaster risk scenarios and help projects achieve the highest rating in the *resilience of* dimension, the World Bank developed an accompanying climate and disaster risk stress test methodology (Hallegatte et al. 2021) and open-source RiST tool,[23] which can be used to stress-test climate impacts on project returns.

Physical Climate Risk Assessment Methodology (PCRAM): Recognizing the lack of consistency in assessing physical climate risks and impacts on infrastructure assets and a communication gap between the infrastructure and financial industries, the Coalition for Climate Resilient Infrastructure started developing the PCRAM in 2020 (IIGCC 2024). An open-source resource that uses real-world case studies, PCRAM provides a common language and framework for the infrastructure and financial sectors. It is designed to inform infrastructure owners and operators of climate-related risks and resilience measures that could protect their assets and improve returns. Supported by the Institutional Investors Group on Climate Change, the methodology is recognized as a crucial tool for enhancing the long-term viability of infrastructure projects.

[23] https://www.worldbank.org/en/topic/climatechange/brief/risk-stress-test-tool.

BOX 4

Nature-based solutions for climate resilience

NbS are actions that work with nature to address societal challenges, benefiting human well-being and biodiversity. Solutions may include the protection, restoration, and sustainable management of natural and modified ecosystems and aquatic systems, including coastlines, cities, watersheds, and rivers. In many cases, NbS can offer both climate resilience and mitigation benefits. The identification, design, and implementation of NbS projects for climate resilience is often best understood using a systems approach at the landscape, city, or watershed level (World Bank 2023a). In an urban setting, runoff reduction measures in green spaces can reduce stormwater flooding as part of a city's drainage system. In a rural valley, a sustainably managed forest can protect communities against landslides while storing carbon and providing sustenance. In a vulnerable coastal area, a healthy mangrove forest can protect against floods and erosion while promoting biodiversity and supporting local livelihoods through ecotourism and fisheries. NbS are underpinned by biodiversity and designed to respect the rights, values, and knowledge of local communities and Indigenous Peoples.

NbS can bring significant economic benefits. Global assessments estimate the benefit-cost ratios of protecting mangroves at more than five-to-one. Globally, mangroves and coral reefs are estimated to contribute to $65 billion and $4 billion in annual avoided damages from coastal floods and erosion, respectively (Beck et al. 2018; Menéndez et al. 2020). Coral reef ecosystem services also extend beyond flood protection to include nature-based tourism, with 30 percent of the world's reefs bringing an annual tourism value of nearly $36 billion (Spalding et al. 2017).

Although global investment in NbS for climate resilience is gradually increasing, funding needs are expected to triple by 2030 (World Bank 2023a). A better understanding of the benefits and value of NbS can be forged through standardized methods and approaches that assess the strength of NbS for climate resilience. Effective guidance, tools, and capacity can maximize the uptake of NbS to address societal challenges and facilitate additional funding and financing options.

Improving the resilience of health and education systems—two key social infrastructure sectors—to current and future climate risks would enable the provision of essential services and support human development. Heat stress and a lack of resilient school infrastructure could severely impact learning outcomes. Investing in climate-resilient school infrastructure is at the core of improving learning outcomes in the face of climate change. The health care system can also support adaptation and build resilience by providing universal health coverage and quality services to reduce deaths and illnesses linked to extreme heat and vector-borne and water-borne diseases that become more common with climate change. Uzbekistan's "One Health" approach is a multisector, collaborative framework implemented throughout the public health system for adequate preparedness, detection, and response to the increased risk of communicable diseases (World Bank Group 2023e). But many countries need to strengthen their policy frameworks and integrate climate risk management and adaptation in their health and education systems.

2.5. Priority Area 3. Help people and firms manage residual risks and natural hazards

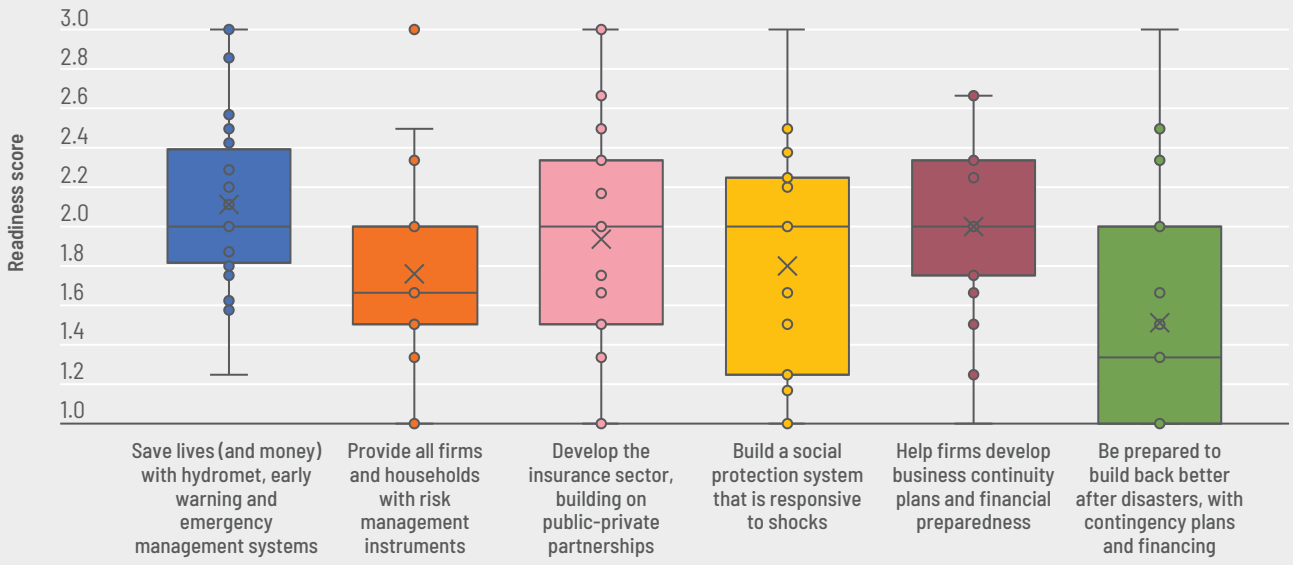
Even the best adaptation and risk reduction strategy cannot reduce risks to zero, so people and firms will need to manage residual risks

and cope with and recover from unavoidable shocks. Governments have a key role to play in helping them do so, and in ensuring that public assets and services can be restored quickly after a disaster or shock. The countries assessed are most prepared in establishing hydromet, early warning, and emergency management systems, and show a wide performance range in their social protection systems to respond to shocks and effectively reach the most vulnerable populations (figure 21).

The largest gap is found in disaster recovery planning and responses, which are crucial for building back after disasters. Recovery mechanisms, such as contingency and reconstruction plans and emergency procurement procedures, can strengthen readiness to respond to and build back better after a shock. Several West African and Caribbean countries are in the early stages of creating such systems. Poland, on the other hand, has established frameworks for resilient recovery and reconstruction—such as its *National Adaptation Strategy to Climate Change* and *Guidelines for Reconstruction after Floods* —and an emergency procurement system with efficient goods and services acquisition for crisis situations, which includes a legal framework and central coordinating body (World Bank, forthcoming).

To prepare for and respond to disasters, firms and households need access to an integrated set of risk management instruments including social protection, access to finance, insurance, and business continuity plans. Some countries—including Peru, Türkiye, Cambodia, Uzbekistan, Armenia, Moldova, Togo, and Cabo Verde—lack a comprehensive national strategy for managing residual climate risks. It is important for countries to approve,

FIGURE 21. AVERAGE SCORE FOR EACH ACTION AREA WITHIN PRIORITY 3: HELP FIRMS AND PEOPLE MANAGE RESIDUAL RISKS AND NATURAL HAZARDS



Source: World Bank staff calculations, based on World Bank country A&R readiness assessments
Note: Each indicator is assigned a score of 1 (nascent), 2 (emerging) or 3 (established) using a range of information sources and methods, including benchmarking against peer countries and expert judgement, and then aggregated with equal weight for each priority area and pillar. Each dot represents a country's average score in the corresponding action area, with the mean represented by a cross and scores between the 25th and 75th percentiles represented in the shaded box.

operationalize, and regularly update such a strategy and ensure they have a coordination mechanism in place. In the Caribbean, insurance penetration, while varying substantially across countries, is generally low. Premiums written account for 8 percent of GDP in Barbados, 6 percent in The Bahamas and Grenada, only around 1.5 percent in Guyana and the Dominican Republic, and less than 1 percent in Haiti and Suriname (Browne et al. 2021).

Adaptive social protection is an efficient tool for protecting poor populations and providing insurance-like services to people without access to market insurance. Innovative systems in Ethiopia, Kenya, and the Philippines, which can be replicated in other countries, can achieve benefit-cost ratios larger than five and reduce well-being losses due to disasters by tens of billions of dollars each year (Hallegatte et al. 2016). These systems modify traditional targeting methods in several ways: factoring in household vulnerability to shocks, integrating and layering programming among poor and vulnerable households in hotspot areas of recurrent shocks, investing in delivery systems and contingency planning to enable the increased responsiveness of programs after a shock hits, expanding social registry coverage with a focus on including high-risk households, prepositioning risk financing to ensure timely funding for response programs, and investing in fostering collaboration and coordination with essential government, NGO, and humanitarian partners (Bowen et al. 2020). Building on shock-responsive or adaptive social protection systems, anticipatory (forecast-based) systems can support households before a disaster occurs, helping them prepare or evacuate. The case studies in section 3.2.5 illustrate the potential of these tools.

Strong hydromet, early warning, and emergency management systems are crucial for saving lives and protecting assets when climate shocks hit a community (box 5), and can serve as a basis for adaptive or anticipatory social protection systems. The Sendai Framework Monitor assesses progress in implementing effective multihazard early warning systems (MHEWS). Despite the global goal of achieving Early Warning for All, only half the global population is currently covered, including less than half of all SIDS (UNDRR and WMO 2023). While 101 countries (52 percent of all countries) reported the existence of MHEWS (figure 22), coverage is lower in Latin America, the Caribbean, and Sub-Saharan Africa. While most countries typically have daily weather forecasts systems and many have some type of early warning system in place, the effectiveness of these systems can be improved across most countries. In particular, hydromet services are most useful when connected to impacts and affected users and sectors. The case studies on end-to-end hydromet services in Bangladesh (section 3.2.1) and the heat-health action plan in India (section 3.2.6) highlight how the value from hydromet services is maximized when the service is an end-to-end solution that includes observation networks, forecast quality, early warning and advisory services and tools, building technical capacity across the entire value chain, and decision-making support in affected sectors.

Tsunami evacuation route sign, Ko Phi-Phi, Thailand. Credit: © holgs | istock.

BOX 5

Early warning system benefit analysis in Indonesia

Over the last 23 years, Indonesia has experienced more than 41,000 disasters due to natural hazards, with 97 percent due to floods, flash floods, droughts, landslides, extreme weather, forest fires, cyclones, abrasion, and other hydromet hazards.[24] In total, these hydromet events have caused more than 8,500 casualties and affected over 1 million houses and 35,000 public facilities. This calls for strengthening not only disaster risk reduction infrastructure but also disaster response and preparedness. An early warning system (EWS) is a critical measure for improving disaster preparedness and strengthening resilience, playing a pivotal role in saving lives. But in 2019, only 27 percent of Indonesia's approximately 7,000 subdistricts had an EWS in place.

A simple descriptive statistical analysis based on official village potential datasets from 2019 indicates the potential significant benefits of EWS in reducing casualties from disasters. It shows that casualty rates from floods, flash floods, and cyclones in subdistricts with EWS are 96, 72.8, and 89.4 percent lower, respectively, than in those without EWS (table 3).[25] A similar trend, albeit with different magnitudes, was found based on a 2011 dataset, underlining the importance of EWS investments for disaster risk reduction to strengthen community resilience toward natural hazards in Indonesia.

TABLE 3. CASUALTIES FROM NATURAL HAZARDS IN INDONESIA, PER EVENT AND PER 100,000 PEOPLE

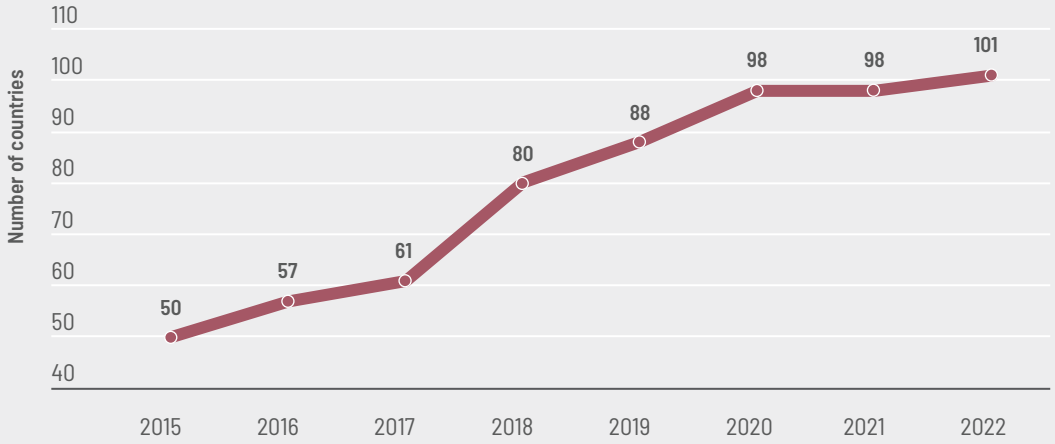
	FLOOD	FLASH FLOOD	CYCLONE
2019			
Subdistricts with EWS	4.29	5.29	2.28
Subdistricts without EWS	109.7	19.44	21.54
2011			
Subdistricts with EWS	11.33	13.1	6.78
Subdistricts without EWS	89.66	14.56	16.69

Source: Pradipta and Jafino, forthcoming

[24] Based on 2023 data from the Indonesian Disaster Information and Data (DIBI) and Indonesia's National Disaster Management Agency (BNPB).

[25] However, these descriptive statistics do not necessarily imply causation. A more comprehensive econometric analysis, considering population density, infrastructure quality, and other factors, is being undertaken.

FIGURE 22. COUNTRIES REPORTING THE EXISTENCE OF A MULTI-HAZARD EARLY WARNING SYSTEM



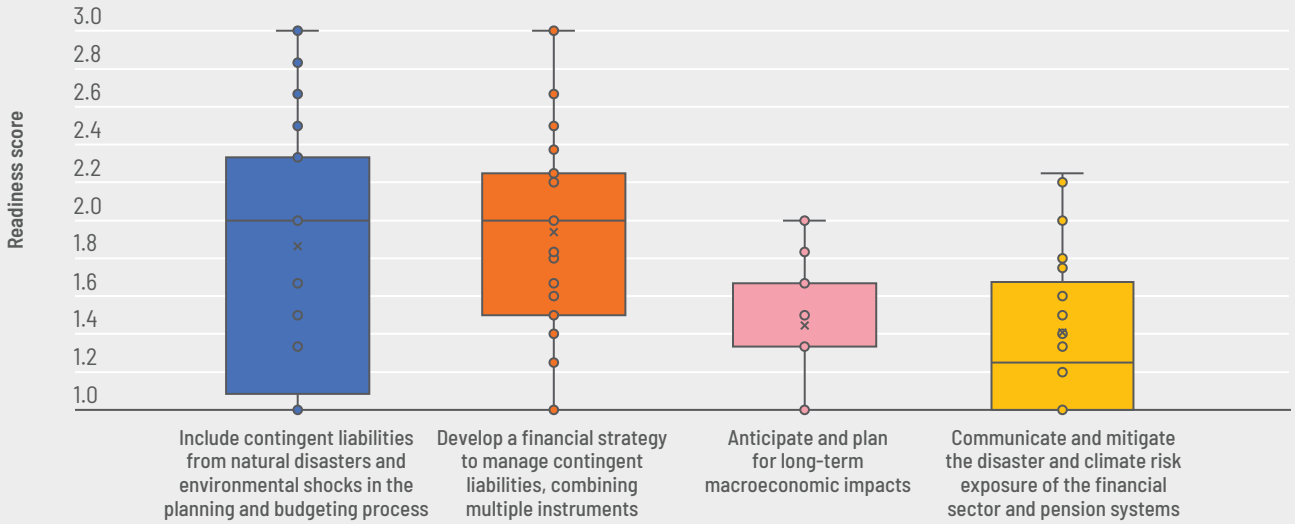
Source: World Bank staff calculations, based on data from UNDRR and WMO 2023.

2.6. Priority Area 4. Manage financial and macrofiscal issues

As climate change impacts increase, they will affect countries' macroeconomic stability, public finance and debt sustainability, and the stability of their financial sector. The A&R assessment results show that, of the six Adaptation Principle pillars, this one has the weakest performance. Many countries demonstrate some progress in including contingent liabilities—such as extreme weather shocks and risk of disasters—in their fiscal plans and budgets, and developing a financial strategy to manage them. But there is less progress in communicating and mitigating disaster and climate risk exposure in their financial sectors and pension systems, and anticipating and planning for the long-term macroeconomic impacts of climate change (figure 23).

Financial regulators can do more to mitigate financial sector and pension system exposure to climate and disaster risks. Apart from integrating these risks in business processes and portfolios with regional- and country-level reporting, countries can require banks, insurers, and large investors to quantify estimates of exposure to natural hazards, introduce regulations around climate and disaster risks, and implement stress testing for these risks (box 6). Of the countries assessed, few have systems in place to manage these emerging risks. Colombia was the first Latin American country to carry out a climate stress test of its financial sector (World Bank Group 2023b). This stress test identified that about 20 percent of Colombian bank corporate loans are in sectors that are highly sensitive to transitions and a broader set of sectors and assets that are vulnerable through value chain effects (Reinders et al. 2021). A recent survey by the Network for Greening the Financial System found that financial sector supervisors and regulators are starting to take more active roles in assessing climate-related risks (NGFS 2024). In Morocco, for example, they carried out a scenario analysis to evaluate the impacts of flood and drought risks to the macroeconomic and financial sector stability (World Bank 2024a). The lack of reliable data and expertise in LICs and the underlying uncertainty of climate risks are obstacles to integrating climate risks in risk management frameworks.

FIGURE 23. AVERAGE SCORE FOR EACH ACTION AREA WITHIN PRIORITY AREA 4: MANAGE FINANCIAL AND MACROFISCAL ISSUES



Source: World Bank staff calculations, based on World Bank country A&R readiness assessments
Note: Each indicator is assigned a score of 1 (nascent), 2 (emerging), or 3 (established) using a range of information sources and methods, including benchmarking against peer countries and expert judgment, and then aggregated with equal weight for each priority area and pillar. Each dot represents a country's average score in the corresponding action area, with the mean represented by a cross and scores between the 25th and 75th percentiles represented in the shaded box.

BOX 6

The European Central Bank: advancements in climate stress tests

The European Central Bank (ECB) is a frontrunner among central banks in designing and executing climate stress tests, providing a blueprint for private financial institutions. Since 2021, the bank has conducted the following four exercises, which differ slightly in scope, scenarios, and methodology, and include both *transition risks* (the consequences of emissions reduction and decarbonization) and *physical risks* (the impacts of climate change and climate-related hazards):

1. A top-down European Union (EU) economywide exercise in 2021 to assess the resilience of nonfinancial corporations and Euro-area banks to transition and physical risk (Alogoskoufis et al. 2021)
2. A bottom-up banking supervision stress test in 2022 to assess the climate risk stress-testing capabilities of the banks in scope (ECB 2022)
3. A climate risk stress test of the Eurosystem balance sheet in 2022 to analyze the sensitivity of its financial risk profile to climate change and enhance its climate risk assessment capabilities (Germann, Kusmierczyk and Puyo 2023)
4. A second EU economywide exercise to analyze the resilience of firms, households, and banks to three transition scenarios, which differ in terms of timing and ambition (Emambakhsh et al. 2023).

The ECB is also involved in designing and executing the Fit-for-55 stress test, a one-off exercise requested by the European Commission to assess the resilience of the financial sector in line with the Fit-for-55 package[26] and gain insights into the financial system's capacity to support the transition to a lower-carbon economy under conditions of stress. Given the cross-sectoral and systemwide nature of this exercise, the ECB collaborated and coordinated with the European Supervisory Authorities, European Banking Authority, and European Systemic Risk Board.

[26] The Fit for 55 package is a set of proposals to revise and update EU legislation and establish new initiatives to ensure EU policies are in line with its climate goal of reducing emissions by at least 55 percent by 2030. https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55/.

Mozambican villagers wait for help at a collapsed bridge after Cyclone Freddy. Credit: Roy Gilham | istock

While there has been progress in integrating climate risks in fiscal planning and budget processes, there is room for improvement in anticipating and planning for the long-term macroeconomic impacts of climate change. Many countries have made progress in incorporating climate risks in national budget processes. For example, Senegal has prepared a "green budget" (*budget vert*) to better address the adverse effects of climate change—including adaptation measures to improve water management in agriculture, resilience to coastal erosion, climate risk management, and biodiversity conservation—and its government has agreed to assess and quantify fiscal risks associated with disasters in the upcoming 2025 budget law. But countries could go further, quantifying the proportion of tax revenues from climate-vulnerable sectors, developing long-term plans to diversify tax revenues from those vulnerable sectors, and incorporating climate and disaster impacts in assessment programs on debt sustainability or the financial sector.

Finally, countries need to anticipate shocks—such as extreme weather events—and develop a financial strategy to manage climate and disaster risks, with clear emergency budget allocation guidelines and ex post financial assistance processes. Disaster risk financing needs should be assessed and combined with both budgetary and market-based instruments, including a process that allows for international aid inflows where relevant. Emerging markets and developing economies are increasingly adopting and implementing disaster risk finance and insurance strategies. For example, Cambodia's National Disaster Risk Financing Strategy and policy outline clear arrangements and instruments for public financial management during emergencies, while the case study on financial preparedness in the Philippines (section 3.2.7) illustrates a comprehensive approach to disaster risk finance that combines multiple tools and instruments to protect the country against frequent and rare events.

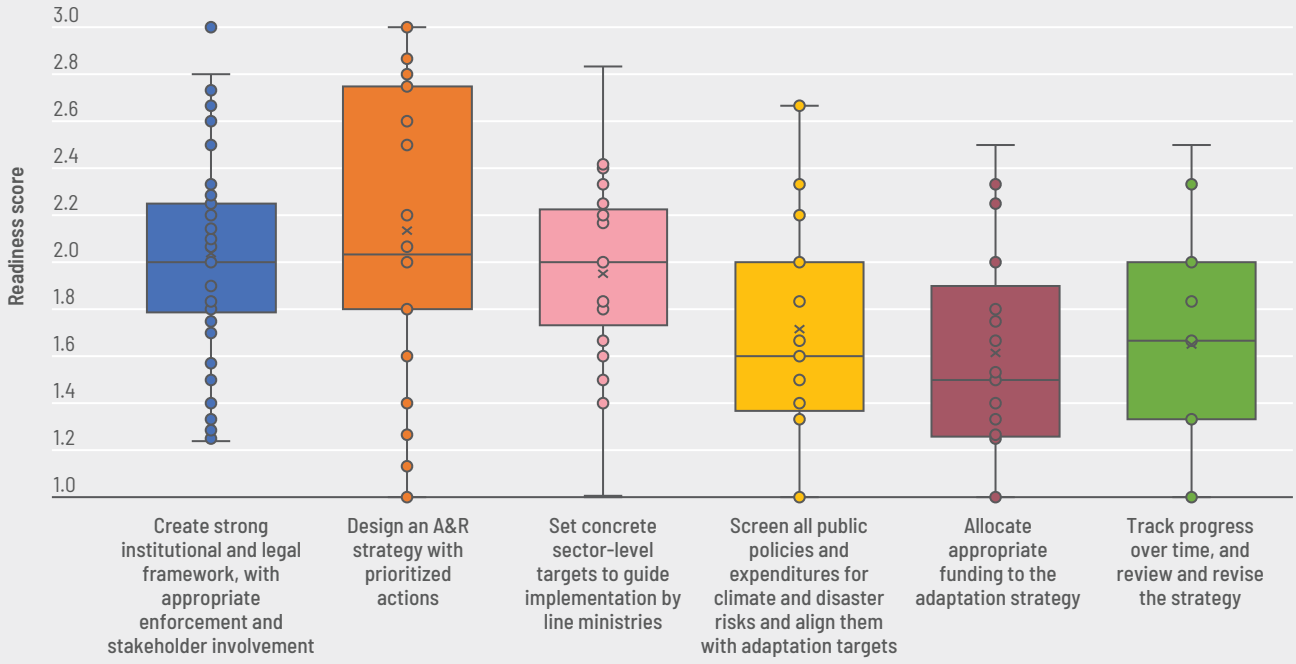
2.7. Applications: legal and institutional framework, implementation, and monitoring progress

Setting up a robust institutional and legal framework that outlines a government's approach, targets and systems for implementation, monitoring, tracking and iterative planning is the cornerstone of effective adaptation. While most countries have made significant progress in establishing climate change and adaptation policy frameworks, many are less advanced in mainstreaming adaptation priorities into development policies and sectoral strategies, allocating enough financing for adaptation and tracking progress (figure 24). Devolving and delegating responsibility for adaptation to local governments is also crucial, allowing these entities to lead efforts on the ground. If not addressed, these gaps can significantly influence the scale, effectiveness, and robustness of adaptation action in the medium to long term. The case study on Vanuatu (section 3.2.8) illustrates the processes for mainstreaming climate risk and resilience into all policies.

2.7.1. Political and legal commitments

Countries have integrated A&R priorities in various policy instruments—most commonly, as part of their NDCs—but coverage and depth vary. For example, Cambodia's NDC outlines a prioritized list of adaptation measures and estimated investment needs ($2.04 billion),

FIGURE 24. AVERAGE SCORE FOR EACH ACTION AREA WITHIN APPLICATION: INSTITUTIONS, IMPLEMENTATION, AND MONITORING PROGRESS



Source: World Bank staff calculations, based on World Bank country A&R readiness assessments
Note: Each indicator is assigned a score of 1 (nascent), 2 (emerging) or 3 (established) using a range of information sources and methods, including benchmarking against peer countries and expert judgement, and then aggregated with equal weight for each priority area and pillar. Each dot represents a country's average score in the corresponding action area, with the mean represented by a cross and scores between the 25th and 75th percentiles represented in the shaded box.

Serbia's NDC mentions adaptation but has not identified any adaptation priorities or related investment needs, and Montenegro's does not address adaptation at all. The variation in coverage of A&R considerations is tied to different factors, including alignment with existing development and planning processes, extent of stakeholder engagement, and knowledge of climate risk and key economic sector vulnerabilities. On their own, NDCs also tend to be less effectively implemented unless the targets and proposed actions are also linked to or integrated in existing development and sectoral plans, policies, and strategies.

To ensure their effectiveness, most countries have integrated adaptation priorities within existing development policies or developed a separate national adaptation strategy or plan, in addition to their NDC. As part of the process of developing an adaptation strategy, some have engaged in the NAP process, a government-led strategic engagement that enables countries to identify and address their medium-and long-term climate adaptation priorities. Importantly, NAPs help countries establish relevant systems and capacities to ensure the integration of adaptation considerations in development planning, decision-making, and budgeting; they also help them establish robust monitoring and evaluation processes, in acknowledgement of the evolving nature of climate change.

Of the countries assessed, a handful have set up a legal framework for climate adaptation and resilience; in others, these are under development, review, or have no legislation to date. Laws and other legal instruments demonstrate a country's accountability toward their climate agenda and set the basis for transparent target setting and implementation. For example, Colombia has created a strong and

Delhi metro station with solar panels being installed on the roof. Credit: amlanmathur/istock.com

extensive institutional framework for climate change, with two key climate laws; Uganda has enacted the National Climate Change Act of 2021; and Peru has established Framework Law No 30754 on Climate Change.

The A&R assessments reveal several challenges in climate policy and legal frameworks. First, priorities outlined in policies often diverge from sectoral development plans and do not consider existing challenges for policy action, particularly where stakeholder engagement was likely limited during policy development. Second, despite ambitious adaptation agendas, implementation gaps persist due to a lack of legislation to bolster action, ineffective governance and enforcement, capacity limitations such as insufficient data, and financial and technical constraints. And third, inadequate monitoring and evaluation systems mean that policy actions can proceed without sufficient oversight or fail to proceed at all.

▲ **Electric bus in operation in the city of Salvador, Brazil. Credit: Joa_Souza/ istock.com**

2.7.2. Governance and institutional framework

Strong adaptation action requires a well-coordinated governance structure, but there is no one-size-fits-all approach, and the effectiveness of governance structures depends on country-specific challenges and capacities. Climate governance structures vary across countries, from centralized bodies within high-level ministries, such as environment ministries, to cross-ministerial coordinating bodies and independent agencies dedicated solely to climate issues. Differences in country governance structures are influenced by factors such as institutional setups, government priorities, influence from interest groups, and levels of political commitment. In Peru, a successful climate action model is centered around a high-level coordinating body with a clear and comprehensive governance framework. Senegal also employs a successful interministerial approach, led by the Ministry of Environment with close engagement with the Ministry of Finance. Involving finance ministries or other governing bodies that influence national budgeting is a key strategy for bolstering climate governance, due to the synergies created between environmental and financial priorities.

Vertical collaboration, which engages stakeholders from national ministries to local governments and community associations, is also crucial for policy implementation. High-level bodies may develop comprehensive policy frameworks, but these can only be translated into effective implementation if local climate actors own the climate agenda and are adequately consulted and integrated in the policy development process (box 7). Policies that do not consider local realities are likely to be less impactful during implementation and can even

have perverse effects, harming the groups that they aim to protect. Guinea's *Approche Guinéenne pour l'dentification des Risques,* a national guide for local governments on how to integrate climate action into local development, was set up to identify and respond to climate-related risk, natural hazards, conflicts, and violence at the local level.

BOX 7

Locally led adaptation action

Globally, there have been growing efforts to cultivate resilience and the capacities needed for climate action from the ground up. Recent years have seen a growing emphasis on locally led adaptation (LLA), which has become a key priority for many governments, donors, and communities living on the frontline of climate change. At the highest level, the interest in adaptation and local climate leadership has culminated in the LLA Principles, established by the Global Commission on Adaptation in 2021, to provide a shared framework to guide governments, donors, and other actors working on climate change adaptation to better integrate local priorities and to channel finance to local actors.[27]

The LLA Principles aim to shift from a top-down approach to adaptation toward a new paradigm where decision-making power is devolved, and resources are redistributed. The principles emphasize local control over priorities and needs, foster inclusivity and equity, and promote local networks and institutions; and their effectiveness is assessed according to local perspectives and realities (Westoby, Clissold and McNamara 2021).[28]

The United Nations (UN) Capital Development Fund designed the Local Climate Adaptive Living Facility (LoCAL)[29] as a standard, internationally recognized country-based mechanism that channels climate finance to local government authorities in vulnerable LICs and MICs. In Mozambique, LoCAL provided over $30 million to 54 of the country's 154 districts and seven municipalities for local climate change adaptation and capacity development. The program has enhanced government contributions to its decentralization policy and built the capacity of local entities. Performance-based resilience grants and capacity development grants have increased the transparency, equity, and predictability of intergovernmental fiscal transfers and public expenditure at local level. Communities are involved in identifying and selecting public adaptive infrastructure through a participatory process, with women selecting approximately 65 per cent of the adaptive development infrastructure and services to date.

In Zambia, the Climate Investment Funds' Pilot Program for Climate Resilience supported the Strengthening Climate Resilience in the Barotse Sub-basin Project. The program emphasized a programmatic and multisectoral approach, promoting community-led adaptation, and ensuring a gender-responsive climate response. The project implemented climate-resilient agricultural practices, built water management infrastructure, established early warning systems, and developed guidelines for mainstreaming climate change in development plans. Based on climate risk and vulnerability assessments, communities identified adaptative measures by diversifying agriculture away from drought-sensitive maize toward cassava, millet, rice, sunflower, aquaculture, and small livestock rearing, and rehabilitated canal to help with flood management and improve water resource availability.

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[27] The LLA Principles (https://gca.org/reports/principles-for-locally-led-adaptation-action/) were developed under the efforts of the Global Commission on Adaptation, co-chaired by Ban Ki-moon, Bill Gates, and Kristalina Georgieva. Subject matter specialists from the World Bank actively participated in shaping the principles through the collaboration that took place under the commission's Locally Led Action Track (LLAT).

[28] As with other approaches, the positive impacts of LLA are not guaranteed. For these to materialize from projects, policies, and other interventions, they need to be intentionally balanced with other measures.

[29] https://www.uncdf.org/local/homepage.

BOX 7 (cont.)

Learning from and building on these global efforts, the World Bank is supporting the scale-up the LLA Principles through a country-driven approach. Such World Bank-financed operations seek to support the local adaptation agenda by: increasing the share of climate finance received and managed at the local level; building capacity and leadership on climate change across all levels of climate governance; ensuring that climate decision-making is participatory and informed by the best available data (including from technical and local experts); and bringing about more sustainable and inclusive climate policies and implementation through cross-sectoral coordination. This World Bank approach, referred to as Locally Led Climate Action (LLCA), includes local investments that might also deliver mitigation outcomes. Examples of LLCA include the Financing Locally Led Climate Action project in Kenya, which strengthens county government capacity to work in partnership with communities to understand climate risks and identify solutions through inclusive and participatory approaches, and establishes county climate change funds to devolve funds to finance these preselected and prioritized climate investments; and the Guinea Support to Local Governance Project (*Projet d'Appui a la Gouvernance Locale*), which supports local climate investments informed by local knowledge and experience.

2.7.3. Monitoring and evaluation capacity

As countries progress with A&R action, it is imperative that monitoring, evaluation, and learning (MEL) systems are in place. Monitoring and evaluating climate adaptation, though inherently complex and challenging, is crucial, given the evolving nature of climate change dynamics and other socioeconomic factors that can exacerbate climate vulnerabilities or hinder climate action. Effective MEL systems can help strengthen policies and actions, expand collective learning, and mobilize domestic and international finance by signaling financial efficiency and accountability. Despite its importance, most countries have limited MEL capacity, highlighting several challenges, including fragmented policy and governance systems and limited capacity. Improved capacity to monitor and evaluate climate impacts and responses is urgently needed across all levels of government, to improve the quality of information flow and reduce time-lags in response. Uganda, one of few countries that has developed an integrated monitoring, reporting, and verification tool, uses a web-based platform hosted by the Ministry of Water and Environment to enhance data collection and inform national-level reporting for developing climate change reports—including its national communications and biennial technical reports—and to track progress on climate action. The tool has been instrumental in enhancing coordination between public and private sector stakeholders in key areas of climate adaptation and mitigation action, including sharing relevant data and tracking financial flows.

CHAPTER 3

Private and public actors are stepping up A&R action

Smiling children from the Samburu tribe in Northern Kenya. Credit: © hadynyah/ istock.com

Although all countries have gaps in their A&R readiness, innovative private and public sector actions across many countries are enhancing adaptation and resilience, dispelling the idea that no progress is being made. The examples in this chapter are not intended to be comprehensive or representative of all interventions (or lack thereof); rather, they demonstrate that significant actions and investments are taking place in both the public and private sectors, with measurable results. The case studies in this chapter have been selected[30] based on a call for proposals, a focus on geographical and sectoral diversity, and their potential of replicability by other countries.

These case studies show that A&R action is having a measurable impact on resilience as well as broader development gains, but they also confirm that adaptation and resilience present a whole-of-society challenge that will require mainstreaming in all (public and private) decisions and policies. The A&R interventions presented here show positive results—for instance, in health, income, or access to reliable energy. But the diversity of interventions, objectives, and result indicators makes it extremely challenging to provide an aggregated estimate of impacts, costs and benefits of adaptation action. Overall, these case studies confirm that adaptation and resilience present a whole-of-society challenge that will require mainstreaming in all public and private decisions and policies (box 8).

[30] A further 20+ case studies have also been collected, which could not be included here. These will be published in the near future, grouped by theme, which will include LLA, disaster risk financing, adaptive social protection, and early warnings.

BOX 8

Cross-sectoral analysis of adaptation impacts and effectiveness

Rexer and Sharma (2024) explore this issue at the intervention level, with a meta-analysis of articles exploring the evidence of adaptation and its impacts. Based on 183 estimates from 80 studies, it finds that adaptive responses mitigate just under 50 percent of the economic damages from climate shocks, but with a major variance across estimates. While the study cannot conclude on the cost-benefit ratio of these measures, it highlights the efficacy of adaptation interventions that can reduce impacts, even though they cannot cancel them.

The analysis also shows that the most effective adaptation strategies typically involve technology adoption and public goods. Household adaptation, for example, is most effective when supported by public goods that make access to markets and basic services more resilient to shocks. On average, publicly supported adaptation strategies—comprising both public goods and government transfers—are more effective than purely private ones.

Burke et al. (2024) evaluate adaptation response to changing climate conditions from a macro perspective. This study examines a range of outcomes—for example, mortality, agricultural productivity, GDP, crime, conflict, and damages from flooding and tropical cyclones—using panel data across geographies (such as US, EU, Africa, Brazil), and explore whether the sensitivity of these outcomes to temperature or other climate variables has changed over time. They find a mixed picture with improvements for some outcomes and impacts (for example, in mortality due to extreme heat), but increased vulnerability in others (such as soy and maize production in Brazil), and no change in many (for example, in the global GDP vulnerability to cyclones). These results remain partial as the data used in the analysis is mainly from more developed countries, with limited coverage of LICs.

This growing evidence on adaptation outcomes is fully consistent with this report, highlighting the large potential of adaptation interventions and the progress along some dimensions—such as mortality from extreme heat—but also gaps in actions from people, firms, and governments.

3.1. Examples of private sector advances in A&R action and investments

In response to recent climate-related shocks and other supply chain disruptions, the private sector has stepped up its actions and investments in resilience. These are not always visible, or recorded, as A&R actions, as climate change is often one among many drivers for implementation. This section explores select examples and emerging results—and draws key takeaways and lessons learned—from the agriculture, energy and infrastructure, and finance sectors.

3.1.1. Case studies from the agriculture sector

The agriculture sector is critical to global food production and ecosystem management and involves a diverse range of actors. From large agribusinesses to smallholder farmers and land managers, they are responsible for producing staple crops and raw materials while also managing vital landscapes and ecosystems. The sector faces increasing challenges from climate change, including rising temperatures, shifting precipitation patterns, and extreme weather events. Rising temperatures and humidity can also accelerate food spoilage, driving the private sector to invest in cold storage chains with other adaptation measures.

The case studies in this section present a sampling of private sector interventions aimed at enhancing climate resilience in the agriculture and food systems. These initiatives, driven by a business need to address adverse weather impacts, include interventions that promote water-efficient irrigation and regenerative agriculture techniques that help boost productivity and offer strong potential for replication and scaling up.

Measures for adverse weather events

Mahindra & Mahindra, India

Mahindra & Mahindra launched Krish-e, an initiative that offers farming solutions via call centers and an easy-to-use digital app available in eight local languages. The company invested in Krish-e to safeguard farmers' incomes, understanding that their ability to buy agricultural machinery depends on having stable crop yields. The Krish-e platform provides personalized support for sustainable and resilient agricultural practices, including crop planning, seed selection, irrigation planning, nutrient management, disease and pest management, and weed control. It also delivers extreme weather alerts, information on seasonal changes, and disease forecasts. These resources empower farmers to transition to more resilient practices, minimizing climate-related risks and improving productivity. To date, Mahindra reports that Krish-e has engaged with over 500,000 farmers, developed 25,000 acres of demonstration plots with them, and established over 100 call centers across the country. By

▲ Cultivating crops and transplanting seedlings in Mozambique. Credit: © Ivan Bruno/istock.com

offering data-driven, personalized support, Krish-e helps farmers manage climate change risks, avoid crop damage, and sustain their livelihoods (WEF and PwC 2023).

EcoEnergia, Mozambique

EcoEnergia helped smallholder farmers recover from the devastation caused by Cyclones Idai and Kenneth in 2019 and strengthened their resilience to environmental and economic shocks by integrating them into the high-value organic cashew value chain. The company leased certified organic trees to farmers and created an organic cashew tree nursery, offering more resilient seedlings. It also provided extension services to help farmers establish these trees on their farms and is setting up a facility to process and sell organic cashews at higher prices. To date, EcoEnergia reports that it has helped 194 farmers produce and sell 2.2 metric tons of organic cashews, form an organic cashew cooperative, and develop long-term strategies to expand the cooperative's membership (Feed the Future 2022).

NWK Agri-Services, Zambia

Agriculture plays a pivotal role in fostering Zambia's socioeconomic development and accounts for 51 percent of the country's labor force; half the population also depends on the sector for their food, primarily through smallholder production (Government of Zambia 2023). Recognizing the demand for financial resilience among farmers, NWK Agri-Services introduced weather index insurance in 2013 to help them recover from climate-related losses and improve their ability to cope with unpredictable weather patterns (Tall et al. 2021). The model enables small-scale farmers to voluntarily participate without requiring subsidies, as NWK prefinances insurance premiums and provides other agricultural inputs in exchange for an agreement to buy the farmers' cotton at the end of the season. The proceeds from cotton sales and any insurance payouts help offset the farmer's outstanding loan with NWK, with the remaining surplus paid out to the farmer. By formalizing business relationships and pooling risks, this model creates a safety net for farmers while ensuring the company's steady supply of cotton. The company reports that this scheme has insured over 52,000 farmers, providing payouts to 23,000 of them after a severe drought in 2015–16. It has improved farmers' resilience and fostered trust within agricultural communities, encouraging them to increase crop yields and expand cotton planting (Tall et al. 2021).

Elderly farmer in Zambia. Credit: © GCShutter/ istock.com

Water-efficient irrigation systems

Olam, Nigeria and India

Operating in 60 countries, Olam, one of the world's largest rice, cotton, cocoa bean, and coffee-producing agribusinesses, has committed to reducing and reusing wastewater in 30 percent of its upstream farms and plantations in water-stressed regions. As part of its Seeds of the Future program in Nigeria, it has facilitated the development of drought- and heat-resistant wheat seeds to support the country's goal of achieving self-sufficiency in food production

(Olam Group 2024). In India, Olam reports that the AtSource+ program has reduced water needs by 19 percent (and GHGs by 48 percent) compared to conventional methods through drip irrigation, rainwater harvesting, cover cropping, and other sustainable agriculture methods.

Resilient agriculture practices

Implementing sustainable agricultural practices enhances climate adaptation and resilience by improving soil health, conserving water, and increasing crop diversity, which collectively strengthen ecosystems against climate-related shocks and ensure long-term food security.

Sucafina, various countries

Sucafina is a coffee trading company that actively engages with coffee plantations and producers to promote sustainable agricultural practices. With a worldwide network of more than 500,000 farmers, the company delivers comprehensive training programs that emphasize regenerative agriculture. Designed to teach farmers how to restore soil health naturally and reduce dependence on synthetic fertilizers, these programs contribute to the company's goal of improving the livelihoods of 350,000 smallholder farmers.[31] The company also provides access to financial mechanisms to ensure farmers can obtain essential inputs and education, even in remote areas. This approach supports sustainable farming practices and fosters resilience against climate impacts (Sucafina 2023).

Unilever, various countries

Unilever's climate resilience initiatives train farmers in sustainable agricultural methods and provide tools and other resources to help them adapt to climate change and help suppliers embed more sustainable sourcing practices. It has also prepared guidance for farmers to prepare biodiversity action plans, which help suppliers meet the Unilever Sustainable Agriculture Code (Unilever 2024). These initiatives are generating global results: in 2023, Unilever reported that 79 percent of its agricultural materials were sourced sustainably, and 99 percent of its cocoa was sourced through certification schemes such as the Rainforest Alliance and Fairtrade.[32]

McCormick & Company, Madagascar

Integrating sustainable agriculture into its operations through its Purpose-led Performance strategy, McCormick collaborates with partners to promote sustainable sourcing practices.[33] For example, in Madagascar's SAVA region, where it sources vanilla, McCormick has invested in multiple projects with partners who train farmers in agricultural practices that lead to sustainability certifications, helping to protect local ecosystems and improve farmers' resilience and livelihoods. These efforts ensure a stable, high-quality supply of vanilla while fostering environmental sustainability and economic stability within the farming communities (PwC et al. 2024). The company reports that over 750 vanilla farmers have been trained in farmer-managed natural regeneration and that overall, its commitments have positively impacted over 44,500 farmers, increasing the resilience of 90 percent of smallholder farmers in its supplier network (McCormick & Company 2023).

Sucden, Côte d'Ivoire

Sucden's agroforestry and forest restoration initiative in Côte d'Ivoire addresses the significant deforestation caused by cocoa farming, which has led to the loss of 26 percent

[31] https://group.sucafina.com/news/sustainable-development/page-3/sucafinas-2030-sustainability-strategy-paves-way-greater-shared-value-coffee1/.
[32] https://www.unilever.com/sustainability/nature/sustainable-sourcing/.
[33] https://www.mccormickcorporation.com/en/responsibility/governance-and-approach/esg-approach.

of the country's humid primary forest between 2002 and 2020. As part of the Cocoa & Forests Initiative, Sucden implemented large-scale agroforestry programs aimed at restoring ecosystems, sequestering carbon, and improving soil fertility, all while supporting farmers' livelihoods. In the 2021–22 season, Sucden distributed 337,000 multipurpose trees to farmers, and provided training on regenerative agriculture. Its off-farm restoration project in Bayota also planted 11,000 native trees across 17 hectares of degraded forest, awarding payments for environmental services to community groups that successfully maintained tree health. This initiative contributed to forest restoration and supported income-generating activities such as maize and cassava cultivation. By integrating sustainable farming with environmental restoration, Sucden reports that the efforts have improved farm productivity, enhanced soil health, and provided long-term resilience against climate change for thousands of farmers and communities (Sucden 2023).

Yara International, various countries

Yara International's Agoro Carbon Alliance incentivizes climate-positive farming, providing farmers and ranchers with agronomic expertise to implement conservation practices that improve soil health, enhance crop yields, protect biodiversity, improve water quality, and lead to increased soil carbon sequestration. The alliance helps farmers monetize sequestered carbon by registering farm carbon credits with global carbon registries, securing buyers after certification, and compensating farmers for the credits generated. Agoro Carbon markets these credits to businesses seeking high-quality, nature-based credits with both mitigation and adaptation benefits, creating a new revenue stream for farmers while promoting environmentally beneficial farming methods. To date, the alliance reports that it has distributed over $12 million to US farmers and ranchers through carbon credit payments (WEF and PwC 2023).

Key takeaways and lessons learned

The case studies in this section highlight the importance of strategic investments in the agriculture sector. By adopting measures to address adverse weather impacts and promote water-efficient irrigation and sustainable agriculture practices, companies are building resilience to extreme weather events while ensuring service continuity.

As well as boosting resilience, investing in adaptation solutions in agriculture and food systems increases revenues. Companies are implementing strategic interventions—such as efficient irrigation, using natural regeneration, and reducing dependence on fertilizers—which increase efficiency and, as a result, build resilience. Building on incentives to maximize revenues and profits, these solutions target implementation barriers, such as a lack of information or know-how.

Farmers and firms face many implementation barriers, and the interventions that successfully remove these barriers are multidimensional, involving capacity building, community engagement, and practical and concrete tools. By tackling barriers to building resilience, solutions facilitate good practice implementation. A consistent package is particularly important for small farmers, who do not have the resources to design their own solutions.

Companies are beginning to take a broader sustainability lens when implementing climate-resilient initiatives in the agriculture sector. This includes considering pollution, biodiversity, and GHG emissions together with resilience investments. This approach is also creating opportunities to use results-based finance and carbon markets to mobilize additional financing.

3.1.2. Case studies from the energy and infrastructure sectors

Power lines in Finland. Credit: © MinttuFin/ istock.com

The energy and infrastructure sectors play a crucial role in powering economies, and their assets and operations are increasingly vulnerable to the impacts of climate change. Energy firms—including producers, utility companies, and distributors—ensure a continuous and reliable supply of fuel and power, while water and transport companies can be responsible for asset construction, operations, and management. Data analytics and artificial intelligence (AI) companies also play an increasingly important role in the energy sector, enhancing resilience by optimizing operations and predicting potential disruptions. The broader infrastructure sector, which encompasses construction, transportation, utilities, and urban development, includes construction companies, real estate developers, engineering consultancies, and infrastructure operators, who are responsible for designing, building, and maintaining roads, bridges, buildings, energy networks, and other essential structures and systems. There is a growing emphasis on climate adaptation to enhance the resilience of the built environment and safeguard critical infrastructure systems.

Infrastructure sectors are also closely connected to key policy priorities and objectives—such as access to reliable, affordable, and secure energy—and investments in these sectors are often lumpy and subject to network effects and economies of scale. As a result, these sectors tend to be heavily regulated, with PPPs, state-owned enterprises, and public subsidies linked to affordability concerns or externalities often playing a large role.

Private actors in these sectors are increasingly investing in climate A&R measures to safeguard their assets, protect communities, and ensure the stability of infrastructure systems. These investments often focus on the risks of heat stress, which affects the durability and efficiency of infrastructure. Higher temperatures can cause building materials to expand and deform, increasing the risk of structural damage, and can put strain on cooling systems, leading to higher energy consumption and costs. Other investments focus on coastal, river, and pluvial floods, which are expected to increase,

threatening residential areas, businesses, and critical infrastructure such as transportation networks and utilities.

Rapid urbanization, population growth, and increasing environmental challenges are also creating a growing need for innovative housing solutions. According to UN Habitat, at least 3 billion people will require better housing by the end of 2030, which means that 96,000 new homes need to be built each day between now and then.[34] Traditional construction methods often struggle to keep pace with demand for affordable, durable, and sustainable housing, while extreme weather events, resource scarcity, and shifting geographical conditions necessitate the development of new types of infrastructure that can quickly adapt to changing circumstances. This need for more resilient, adaptable, and efficient housing solutions drives the exploration of alternative construction technologies. Existing housing also needs to be retrofitted and repurposed through passive design and other measures.

Measures to address climate vulnerabilities

To address climate vulnerabilities, energy companies are embedding climate risk assessments, investing in resilient infrastructure, and upgrading facilities to withstand extreme weather. These efforts include burying power lines, reinforcing dams, enhancing energy systems, and prioritizing essential post-disaster services for vulnerable communities through resilience hubs. These interventions aim to mitigate risks and adapt to the growing impacts of climate change.

Energy Development Corporation (EDC), Philippines

Backed by a consortium led by Macquarie Infrastructure and Real Assets, EDC identified a critical need to strengthen its infrastructure against climate-related disasters, such as intense typhoon winds and increased rainfall. Using updated models that factored in evolving natural hazards, the company embedded climate risk assessments into its decision-making, investing ₱313.8 million (about $6.2 million) in 2018 to improve the resilience of its most critical infrastructure points, guided by advanced light detection and ranging (LIDAR) mapping and flood modeling. This investment helped protect future revenues while minimizing potential losses and repair costs. EDC also enhanced its collaboration with municipal agencies and local communities and created a disaster prevention and recovery unit to train first responders in host communities (Tall et al. 2021).

Elenia, Finland

A major electricity distribution company, Elenia developed its Weatherproof Underground Cable Network to mitigate risks and ensure more reliable power delivery (Tall et al. 2021). It implemented a comprehensive strategy to place all new power lines underground, making them resilient to extreme weather events and aligning with the Finnish Electricity Market Act, which mandates that power outages must not exceed six hours in zoned areas and 36 hours in others by 2028 (Elenia 2023). The company invested over €1 billion between 2009 and 2019 to bury power lines, using upfront capital investment funded through anticipated future cost savings (Tall et al. 2021). It also conducted self-assessments to identify weather-related disruptions and align its underground cable network expansion with other corporate goals. Although the initial costs of underground cabling were higher than traditional overhead lines, the buried network reduces maintenance costs and revenue losses from outages over its lifetime. Storm damage repairs and tree clearing are

[34] https://unhabitat.org/topic/housing.

Itaipú Dam in Paraná state, Brazil. Credit: © Rodrigo A. Rodriguez Fuentes/ istock.com

no longer required, further supporting cost-effectiveness. Elenia aims to increase the proportion of underground cabling to 75 percent by 2028 (Tall et al. 2021). Reducing overhead lines also makes more land available for forestry, agriculture, and other productive activities.

Hydro-Québec, Canada

To address the increasing frequency and severity of extreme weather events, Hydro-Québec's comprehensive Climate Change Adaptation Plan[35] includes reinforcing transmission lines, replacing wooden poles with stronger composite ones, and enhancing vegetation management around distribution systems. These interventions are designed to ensure the reliability and safety of the company's energy generation, transmission, and distribution infrastructure. Hydro-Québec's proactive approach involves continuously monitoring and updating the plan to integrate the latest scientific advancements and best practices in climate resilience. These measures enhance the resilience of its infrastructure, reducing the risk of disruptions caused by extreme weather.

Itaipú Binacional, Brazil

The Itaipú Dam, which is responsible for 90 percent of Paraguay's electricity and 10 percent of Brazil's power, uses NbS to protect critical energy infrastructure. To ensure resilience, Itaipú Binacional planted over 44 million trees in the company-owned area around the dam, reforesting, restoring, and conserving 101,000 hectares of land and 421 micro-watersheds. These efforts have improved water quality and reduced sedimentation, enhancing the dam's operational efficiency and resilience against extreme weather events (Resilience Shift 2020).

Southern California Edison (SCE), United States

This major US electric utility completed a climate adaptation vulnerability assessment (CAVA) to identify climate-related risks to its assets and operations (Bailey et al. 2024). Using global climate models to assess the company's exposure to wildfire, sea level rise, extreme heat, precipitation, drought, and other climate hazards, the CAVA identified potential adaptation measures to mitigate these risks. It also

[35] https://www.newswire.ca/news-releases/hydro-quebec-releases-its-climate-change-adaptation-plan-852816013.html.

highlighted the importance of integrating future climate scenarios into long-term planning across both government and industry sectors. Having pinpointed the communities most affected by disruptions to electricity services, SCE then partnered with environmental, community, and faith-based organizations to develop effective outreach strategies (Bailey et al. 2024). These efforts culminated in its Climate Adaptation Community Engagement Plan, which provides targeted approaches for sharing information with customer communities based on their needs. The CAVA gave SCE valuable insights into the vulnerabilities of its electric grid and informed its strategies to make the grid more resilient. Collaborating with local organizations and authorities produced a comprehensive engagement plan, tailored to meet the unique needs of different communities, that enhances awareness of climate impacts and empowers communities to take proactive measures.
The CAVA also emphasized the importance of immediate funding and investment in climate adaptation initiatives.

Offshore wind turbines, Taiwan.
Credit: © Yu-chen Huang/istock.com

Utilidata, United States

Utilidata's Karman platform[36] enhances the resilience of electrical grids to climate-related disruptions. Karman's real-time monitoring and AI-driven response capabilities enable utilities to swiftly identify and resolve issues, such as voltage spikes and outages caused by environmental factors like severe storms or falling tree branches. This ability to detect and mitigate disruptions before they escalate improves the grid's overall reliability, allowing communities to continue functioning during climate-related events. By preventing costly outages and ensuring system stability, this helps energy infrastructure adapt to a more volatile climate, ultimately enhancing societal resilience. These capabilities reduce the vulnerability of critical infrastructure and help utilities maintain uninterrupted service, enabling smoother adaptation to the unpredictable conditions of a changing climate.[37]

Ørsted, Taiwan

To enhance the climate resilience of its offshore wind farms in the face of increasing typhoon threats in the Taiwan Strait, Danish energy company Ørsted implemented a Dual-Doppler Radar System. The first of its kind applied to offshore wind, this system collects high-resolution wind data from two radar stations, generating three-dimensional (3D) field images that allow the company to predict wind speeds and patterns during extreme weather. This enables the company to make pre-emptive adjustments to turbine operations, significantly reducing the risk of damage and power outages during storms. The system strengthens the resilience of Ørsted's Greater Changhua 1 and 2a offshore wind farms by ensuring operational stability even during severe weather.[38]

[36] https://utilidata.com/.
[37] https://www.forbes.com/sites/erikkobayashisolomon/2024/04/23/utilidatas-ai-sharpens-the-grids-edge/.
[38] https://orsted.tw/en/news/2021/11/radar-operation.

Waterfowl swimming in a pond, South San Francisco Bay Area. Credit: © Sundry Photography/istock.com

Philanthropic initiatives

Pacific Gas and Electric Company (PG&E), United States

PG&E's Resilience Hubs Grant Program in California aims to establish resilience hubs that provide essential post-disaster services—such as power, shelter, food, water, and information—particularly to marginalized and vulnerable communities. These initiatives are essential in enhancing community resilience and ensuring continued support in times of crisis, as wildfires, flooding, and extreme weather events become more common. Each year, PG&E allocates $400,000 to fund government and nonprofit organizations in assessing, designing, and building resilience hubs.[39] These grants enable recipients to conduct feasibility studies, evaluate needs, develop effective resilience strategies, and create vital support systems in marginalized communities. By ensuring access to electricity, food, water, and other essentials, the hubs improve community resilience during power outages and disasters.

Arup, Mexico

This global professional services firm collaborated with nonprofit organizations in Mexico to develop scalable solutions that protect low-income communities from heat stress (PwC et al. 2024).[40] Through the Arup Community Engagement Global Challenge, it has allocated $330,000 in in-kind funding to supplement a $125,000 grant from the Million Cool Roods Challenge.[41]

Meta, United States

This multinational technology company is contributing to a multistakeholder initiative to protect local communities from climate change impacts. The Strategy to Advance Flood Protection, Ecosystems, and Recreation along the San Francisco Bay (SAFER Bay) program is a partnership between the City of Menlo Park, PG&E, and Meta that integrates green and gray infrastructure to counter increased flooding and sea level rise. The program aims to build levees and other infrastructure to enhance Meta's campus resilience while protecting key

[39] https://www.pge.com/en/about/giving-locally/resilience-hubs-grant-program.html.
[40] https://cdn.prod.website-files.com/61422895c7ecdd5272d17082/623a1215c99eb9b74b722565_Project%20summary.pdf.
[41] https://challengeworks.org/challenge-prizes/million-cool-roofs-challenge/.

infrastructure like the PG&E substation and segments of state highways. It will also improve access to the San Francisco Bay shoreline for recreation and restore wildlife habitats within a nearby refuge (WEF and PwC 2023). Meta's commitment to funding levee construction around its campus and the neighboring community serves as a "local matching fund commitment", unlocking Federal Emergency Management Agency grants for the project and allowing the program to leverage the maximum grant for the project, enabling comprehensive flood protection efforts.

Business initiatives

ICON and Boklok, various countries

These two companies are pioneering innovative housing solutions using advanced construction methods in Europe and North America. ICON's Vulcan system produces 3D-printed homes up to 3,000 square feet that comply with the International Building Code and offer greater durability than traditional concrete masonry units, making them more resilient to extreme weather. ICON is working with US home construction company Lennar to build a community of entirely 3D-printed homes in Austin, Texas.[42] Boklok, a collaboration between Skanska and Ikea, constructs flat-pack homes from sustainably sourced Scandinavian wood. To date, it has built around 14,000 houses in Sweden, Finland, Norway, and the United Kingdom, generating $250 million in revenue for the adaptation-focused manufacturer with a focus on climate-conscious and affordable housing.[43]

Architect Francis Kéré, Burkina Faso

Architects across the world have been increasingly considering vulnerability to extreme heat as an important consideration in public and private building design, often using traditional African or Middle Eastern architecture as inspiration. Francis Kéré, who received the Pritzker prize in 2021, illustrates this movement with his work on heat-resistant schools in Burkina Faso, built from local material and at low cost. The Gando primary school or Noomdo orphanage improve thermal comfort thanks

Primary school by Diébédo Francis Kéré, Gando, Burkina Faso. Credit: © Catherine Slessor/The Architectural Review

[42] https://hbr.org/2022/08/its-time-to-invest-in-climate-adaptation.
[43] https://www.systemair.com/en/expertise/case-studies/boklok-housing-sweden.

to passive ventilation and shade, even during extreme temperature episodes.[44]

Architect Yasmeen Lari, Pakistan

Pakistan's first woman architect, Yasmeen Lari designed earthquake- and flood-resistant bamboo homes in 2005 after an earthquake, and the house model has since been distributed across Pakistan. She was awarded the Royal Gold Medal from the Royal Institute of British Architects in 2023 for her work in humanitarian architecture.[45] One important consideration in the design is ensuring that it can be applied by homeowners who are building (or rebuilding) their own dwelling.

Key takeaways and lessons learned

The case studies in this section highlight the importance of strategic investments in infrastructure, partnerships, and community engagement within the energy and infrastructure sectors. By reinforcing key assets and integrating climate risk assessments, companies are building resilience to extreme weather events while ensuring service continuity.

Proactive infrastructure resilience design is cheaper than retrofitting, and companies are changing the way they build to make more resilient infrastructure. The cost of making infrastructure resilient during initial construction is only a fraction of the total project cost, and retrofitting resilience to existing infrastructure can cost 4–10 times more (Hallegatte, Rentschler and Rozenberg 2019). Energy and infrastructure companies are increasingly investing in resilience to withstand climate change-induced extreme weather events.

Workers laying underground electrical power lines in Jakarta Indonesia. Credit: © Yamtono_Sardi/istock.com

Strategic coalitions and PPPs are needed to mobilize resources for adaptation. Partnerships between private companies, government agencies, and nonprofits are essential for pooling resources and securing funding, and to ensure the innovation and investment potential of the private sector contributes to building resilience.

Focusing on vulnerable communities shows good corporate social responsibility and builds the resilience of clients. Some actors have implemented targeted solutions for poor and vulnerability communities, and these interventions combine social responsibility with a strong business rationale, as businesses benefit from having more resilient clients.

[44] https://www.architectural-review./today/primary-school-by-diebedo-francis-kere-gando-burkina-faso.
[45] https://www.architectural-review.com/buildings/bamboo-rising-lari-octa-green-shelters-by-yasmeen-lari-in-sindh-province-pakistan.

3.1.3. Case studies from the finance sector

Financial analysis. Credit: © Chartchai Kanthathan/istock.com

The finance sector plays a pivotal enabling role in addressing climate change by mobilizing capital for A&R efforts, including in the agriculture, energy, and infrastructure sectors. A range of actors—from private investors to banks and development finance institutions—provide the necessary funding for climate solutions, especially in vulnerable regions and sectors. Central banks are increasingly using scenario modeling and climate risk stress testing to evaluate potential financial system impacts from climate change. Financial regulators use other tools to build resilience, including supervisory guidelines and taxonomies with A&R measures to help manage climate risk. But despite these advancements, many emerging market countries, particularly LICs, face broad challenges due to weak fiscal conditions, small banking sectors, and undeveloped capital markets, which collectively limit their ability to tap into private capital for A&R investment. Concessional finance and other financial tools can address some of these challenges. Better financial infrastructure, including resilient payment systems, effective credit infrastructure, and incorporating financial inclusion data into A&R needs assessments, can help spur more private action.

Investor frameworks

Investors need clear and actionable frameworks to guide their A&R investments, and several promising frameworks are emerging. The frameworks need to help investors address two challenges: the additional costs of improving resilience and the growing number of investments that have resilience as their intended outcome. Emerging frameworks include the *Climate Resilience Investments in Solutions Principles (CRISP),* which outlines sector-specific solutions and investment opportunities, helping investors see resilience as a catalyst for growth (GARI et al. 2024); the *Guide for Adaptation and Resilience Finance,* which provides a process-based approach to identifying and assessing adaptation investments in specific sectors and subsectors, with corresponding metrics that can be used to report on A&R outcomes (UNDRR, Standard Chartered Bank and KPMG International 2024);

the *Gold Standard for the Global Goals*[46] and *Resilient Cities Catalyst Adaptation Framework*,[47] which both integrate scientific data and stakeholder engagement to ensure adaptation projects are both sustainable and profitable; and the *Climate Bonds Resilience Taxonomy*,[48] which provides a comprehensive classification system and interim eligibility criteria for climate adaptation and resilience investments. Ratings agencies are also taking action. For example, *Moody's Ratings*[49] incorporates physical climate risk assessments into credit analysis using a framework that highlights sectors with high exposure to climate risks and advocates for enhanced reporting and collaboration between public and private entities.

Leading climate and private sector organizations have defined core actions that businesses can take to reduce risks and enhance adaptive capacity to climate change. Regulatory changes impact businesses globally by driving comprehensive reporting on climate-related risks and strategies. For example, the EU *Corporate Sustainability Reporting Directive*[50] mandates detailed sustainability disclosure. In parallel, business-led taxonomies have evolved rapidly. The recommendations of the Task Force on Climate-related Financial Disclosures, which have been integrated into the International Sustainability Standards Board,[51] help to ensure transparency and consistency in climate-related financial disclosures, emphasizing the importance of understanding and mitigating climate risks to ensure long-term corporate resilience. The Climate Bonds Initiative's *Climate Resilience Classification Framework* provides a standardized approach for investors to assess and align their investments with resilience goals, mobilizing capital markets for climate adaptation and resilience (UNDRR 2023). The University of Oxford's Resilient Planet Finance Lab has compiled a list of more than 35 jurisdictional and non-jurisdictional adaptation taxonomies that seek to identify adaptation investments (Spacey Martín, Ranger and England 2024).

Finance mobilization

Through strategic partnerships and innovative fund structures, multiple organizations and initiatives are beginning to channel capital into climate solutions for vulnerable populations and regions. The following funds and initiatives aim to drive private sector investment in climate adaptation and resilience.

The Climate Resilience and Adaptation Finance and Technology-transfer facility (CRAFT) Fund[52]

A growth equity fund managed by the Lightsmith Group, CRAFT helps companies focus on adaptation-relevant products and services, using a layered fund structure to leverage concessional funds and mobilize private investment. It also offers technical assistance. The fund co-invests in companies in developed and developing countries, with CRAFT taking 15–45 percent ownership. This structure enables significant gross returns for commercial investors, in line with expectations for growth equity. To date, CRAFT has received nearly $200 million in signed commitments and has provided learning for the subsequent Global Environment Facility's Challenge Program for Adaptation

[46] https://globalgoals.goldstandard.org/pilot-adaptation-requirements/.
[47] https://www.rcc.city/climate-adaptation-standard.
[48] https://www.climatebonds.net/.
[49] https://www.moodys.com/web/en/us/capabilities/climate-risk.html.
[50] https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/. company-reporting/corporate-sustainability-reporting_en.
[51] https://www.ifrs.org/sustainability/tcfd/.
[52] https://lightsmithgp.com/craft/.

Innovation to test and model innovative models for engaging private sector actors in adaptation action (Tall et al. 2021).

Catalyst Fund[53]

A thesis-driven investor that backs founders in building climate A&R solutions in Africa, the Catalyst Fund also convenes a global network of more than 200 investors and other ecosystem partners. Through its previous two accelerator funds, its 61 portfolio companies have gone on to secure more than $800 million in follow-on funding, and currently serve more than 14 million underserved individuals. The fund is backed by FSD Africa Investments, UK International Development, CISCO Foundation, and the Global Environment Facility's Challenge Program for Adaptation Innovation.[54]

Kuali Fund[55]

A €300 million fund managed by GAWA Capital, Spain's leading impact investing firm with €220 million of assets under management, the Kuali Fund focuses on investing in financial institutions and climate solution providers to increase access to climate solutions for smallholder farmers and small businesses (PwC et al. 2024).

GAIA Fund[56]

With a target size of $1.48 billion, this private debt blended finance platform finances climate adaptation and mitigation projects, with a respective split of roughly 70/30 percent of the fund's capital. GAIA provides senior loans of $5–75 million to sovereign, sub-sovereign, and quasi-sovereign borrowers to channel capital into private sector projects in emerging markets. It targets 25 emerging markets and aims to allocate at least 25 percent of its capital to Least Developing Countries and SIDS. It also has a $50 million technical assistance facility to support project development.[57]

Business potential of adaptation SMEs

Adaptation SME Accelerator Project

Led by the Lightsmith Group, this project seeks to build an ecosystem for early-stage companies in emerging markets that have technologies, products, and services that can be used to build resilience to the physical impacts of climate change. It identifies adaptation SMEs using a comprehensive taxonomy for A&R products and services and has a global directory of 284 A&R SMEs, representing 80 countries.[58]

De-risking investments and tackling information asymmetries

Public-Private Infrastructure Advisory Facility (PPIAF)[59]

There is often insufficient integration of climate risks into PPP planning and implementation phases, leading to vulnerable infrastructure and missed opportunities for leveraging private investment. The facility developed sector-specific Climate Toolkits for Infrastructure PPPs (CTIP3) to facilitate the integration of climate mitigation and adaptation considerations into infrastructure projects at the upstream and midstream stages of the PPP lifecycle.[60] These

[53] https://www.thecatalystfund.com/.
[54] https://www.cofides.es/en/noticias/notas-de-prensa/green-climate-fund-approves-kuali-fund-first-operation-submitted-spanish.
[55] https://www.cofides.es/en/noticias/notas-de-prensa/green-climate-fund-approves-kuali-fund-first-operation-submitted-spanish.
[56] https://www.gaiasf.org/.
[57] https://climatefundmanagers.com/2023/12/04/climate-fund-managers-appointed-investment-manager-of-gaia-lp-a-usd1-48-bn-target-climate-focused-emerging-market-private-debt-platform/.
[58] https://climateasap.org/the-adaptation-sme-directory/.
[59] https://www.gihub.org/.
[60] https://www.worldbank.org/en/topic/sustainableinfrastructurefinance/brief/climate-toolkits-for-infrastructure-ppps.

toolkits—available for the energy (hydropower, solar, and wind), water and sanitation, transport, and digital/information and communications technology sectors—help users assess the enabling environment and institutional capacity and embed climate considerations into potential PPP projects. Today, the toolkits are used in 20 countries and have resulted in the mobilization of private capital for projects that might otherwise have been deemed too risky or unprofitable due to climate vulnerabilities. Examples of these projects include:

- **Technical advisory support in Angola, piloting the water and sanitation sector CTIP3 tool to integrate climate guidance into the water sector's PPP framework:** The toolkit assessed climate mitigation and adaptation risks to a water infrastructure PPP investment pipeline, resulting in the development of a climate-inclusive project screening methodology, feasibility studies for four eligible projects, and a water PPP pipeline incorporating low-carbon and climate-resilient infrastructure, enhancing the sustainability of the Water PPP Program.
- **Applying the CTIP3 tool in Ghana to integrate climate guidance into the PPP framework and pipeline development:** This pilot aimed to mainstream climate mitigation and adaptation into the national PPP program, focusing on regulatory reforms and project prioritization. The project developed climate-smart screening criteria, prepared a diagnostic report on Ghana's climate-smart investment environment, and identified a shortlist of climate-resilient PPP projects for the Ministry of Finance.
- **Supporting a study in Mozambique applying the transport sector CTIP3 tool to assess flooding risks to a proposed bus rapid transit PPP for the Maputo area:** The study evaluated how extreme precipitation scenarios might impact ridership and operational continuity, as well as the overall commercial viability and bankability of the project. The results were used to inform climate-resilient design standards and recommend an optimal PPP model and payment mechanism to mitigate climate risks and ensure the project's long-term viability.

Innovative finance mechanisms

Microfinance for Ecosystem-based Adaptation (MEbA) project

In collaboration with the UN Environment Programme and Yapu Solutions, BNP Paribas developed the MEbA project in 2012 (UNEP 2020), providing microfinance products and solutions to vulnerable rural and periurban populations in Sub-Saharan Africa and Latin America. The project's goals included improving climate resilience, enhancing the capacity to manage climate information and risks, and promoting ecosystem-based adaptation (EbA) options. The MEbA Biodiversity Platform gives financial service providers access to enhanced digital credit analysis tools (UNEP 2020), such as detailed cash flows for agricultural activities, green microcredit verification indicators, and climate and biodiversity risk indicators. It helps financial institutions integrate these risks into their credit decisions, laying the groundwork for accessing new funding sources, such as green credit lines, and disbursed nearly 18,000 EbA loans with private investment of over $30 million by September 2020.[61] The project also trained 4,385 farmers and established 13 demonstration farms to showcase best practices and popular EbA solutions, such as solar dehydrators, crop rotation, and organic agriculture.

[61] https://unepmeba.org/project-approach/.

Scientist assessing carbon sequestration rates in a tidal seagrass bed. Credit: © Tenedos/ istock.com

Climate Smart Innovation Hub

The Mastercard Center for Inclusive Growth and Climate Innovation for Adaptation and Resilience Alliance[62] collaborate on a project that leverages digital finance to support low-income populations affected by climate change. As part of this, they launched the Climate Smart Innovation Hub[63] to connect entrepreneurs with climate scientists, financial service providers, and investors to develop tools that enhance financial resilience and environmental sustainability. The Mastercard Foundation also established the Fund for Resilience and Prosperity,[64] a seven-year, $126 million fund supporting SMEs in agriculture, climate adaptation, and the digital economy across Sub-Saharan Africa, which has supported over 70 solutions aimed at driving financial resilience and promoting environmental sustainability globally and compiled a gallery of products[65] to educate investors on climate-smart financial products and business models.

Insurance PPPs[66]

Closing the insurance protection gap requires collaboration between governments, the insurance industry, regulatory and supervisory authorities, and development partners. This can range from providing and sharing risk information, integrating approaches to risk reduction and financial resilience, and sharing risks among private

[62] https://www.mastercardcenter.org/; https://www.cifaralliance.org/.
[63] https://www.csih-cifar.org/.
[64] https://frp.org/.
[65] https://www.csih-cifar.org/category/all-products.
[66] These examples are discussed in more detail in the World Bank Technical Contribution to the 2024 G7 Climate Change Mitigation Working Group: *Challenges and Opportunities of Operationalizing Public-private Insurance Partnerships for Natural Hazards in Developing Countries.*

insurers and governments. Public intervention can foster competitive insurance markets by improving risk market infrastructure, including data systems, risk models, and legal frameworks. It can also build on existing public social protection programs, which reduces startup costs and entry barriers, therefore lowering insurance premiums and benefiting policyholders. Supervisors play a critical role by ensuring the stability, fairness, and resilience of catastrophe risk insurance systems. Private insurers can contribute their technical capacity in underwriting, risk assessment, and claims management, as well as their financial capacity in risk-bearing. The industry also has a role to play in revealing the cost of risk—through risk-based insurance premiums—incentivizing proactive risk management and driving risk management standards through society. The following examples illustrate this diversity of approaches.

The Turkish Catastrophe Insurance Pool (TCIP) aims to increase market penetration and offer affordable insurance. The government of Türkiye provides a financial guarantee and enabling environment, allowing private insurance companies to compete to operate the TCIP and act as agents. TCIP is mandatory in urban areas and insures more than 50 percent of the population. It has also achieved efficiency and speed of payouts, as demonstrated following the 2023 earthquake. The World Bank supported the establishment of the TCIP through a combination of technical assistance and lending, including contingency finance.

Morocco developed a dual catastrophe insurance system that builds on market-based insurance and solidarity principles to protect insured and uninsured households against disasters. It covers insured households through a compulsory extension of guarantees against catastrophe risks in all property insurance policies. But, as insurance penetration is low (<5 percent), the government established the Solidarity Fund against Catastrophic Events (FSEC) to protect uninsured households. Following the Al-Haouz Earthquake in 2023, the FSEC unlocked around $300 million to cover eligible losses, of which $275 million came from the FSEC's (parametric) reinsurance policy.

In 2019, Indonesia transferred risks related to almost 11,000 schools, hospitals, government offices, and other public buildings to the insurance market through its state assets insurance program, ABMN. The program is insured by a consortium of more than 10 domestic insurers backed by international reinsurance. Payouts—for example, after the 2020 Jakarta floods and 2021 Mamuju earthquakes—have enabled ministries to repair assets and minimize public service disruptions.

Key takeaways and lessons learned

The case studies in this section highlight the pivotal roles private sector financial interventions can play in scaling climate A&R efforts. These range from directly investing in adaptation-focused SMEs to developing microfinance and sustainability-linked loans and deploying innovative mechanisms such as weather index insurance. By leveraging blended finance models and de-risking investments, private actors are addressing the significant funding gap in vulnerable and emerging markets. Blended finance is most effective when it minimizes concessionality, targets market failures to avoid crowding out private finance, and generates transparent results.[67] Strategic partnerships with governments, development agencies, and philanthropic organizations

[67] https://www.ifc.org/en/what-we-do/sector-expertise/blended-finance/how-blended-finance-works#principles.

enhance these efforts, ensuring financial resources are effectively mobilized.

Adaptation SMEs have promising business potential. SMEs can play an important role in addressing climate resilience but face the strongest barriers to action. Given their limited capacity, financial firms can boost adaptation by offering tailored support and building ecosystems for growth-stage companies in emerging markets.

PPPs can provide de-risking investments and help build insurance markets, but more public and blended finance is needed. Public institutions can provide guarantees and co-financing to attract private capital to adaptation projects. They can also use first-loss equity to encourage greater participation of risk-averse private investors, combined with technical assistance to help shape projects. But more public resources are needed—for example, through blended risk-mitigation tools—and aligning with national adaptation priorities ensures that capital flows to the most climate-vulnerable regions.

Innovative finance tools, such as microfinance products for climate resilience, can empower vulnerable populations. Leveraging digital platforms and integrating climate and biodiversity risks into credit decisions has opened new funding opportunities for EbA projects. Financiers can also leverage digital and financial technology, enabling more informed decision-making and improving resilience outcomes.

Targeted support promotes inclusive growth. Many initiatives highlight the need for targeted support to ensure marginalized groups benefit from climate resilience efforts. Empowering these groups promotes inclusive economic growth while enhancing overall climate resilience.

3.2. Examples of public sector advances in A&R action and investments

Private sector initiatives and investments toward resilience are often dependent on—or constrained by—the policy and regulatory environment; fortunately, governments and local authorities are becoming increasingly active in promoting adaptation and resilience. This section offers a first selection of case studies that emphasize innovative interventions that are already showing results. Because of the diversity of required interventions, they provide only a partial view of the full landscape of resilience-enhancing interventions. This selection will be complemented over the coming months with more case studies to create a repository of successful A&R interventions that can be replicated.

3.2.1. Building end-to-end hydromet services in Bangladesh

Adequate hydromet services can play a substantial role in unlocking Bangladesh's development potentials. With one-third of agricultural GDP estimated to be lost due to climate variability and extreme events by 2050, and cropland expected to shrink by 18 percent in the south and 6.5 percent nationally by 2040 (World Bank Group 2022a), addressing weather and climate risks is vital to ensure the country's sustainable economic development. Beyond early warning systems for natural hazards, hydromet services can significantly improve productivity in the agriculture sector, which contributed around 11.5 percent to national GDP (Ministry of Finance 2022) and employed 37 percent of the national workforce in 2022.[68]

Hydromet service provision is highly technical in nature; and with the technology constantly evolving, many countries struggle to keep up. To perform at their best, hydromet services need adequate human and financial resource levels, and recurring investment to replace and upgrade observation systems, computer systems, models, and staff capabilities. Although Bangladesh's eighth national five-year plan (2021–25) sets out several strategic objectives for hydromet service provision, its maturity level score is 2.7 out of 5,[69] with key areas for improvement in human capacity, maintenance of infrastructure, information and communication technology infrastructure and data management, and user interactions and stakeholder involvement (Alliance for Hydromet Development 2024).

▲ **Road in the Rangapani area of Bangladesh submerged in knee-deep water as a result of flooding. Credit: © Mohammad Shajahan/ istock.com**

[68] https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=BD.

[69] Based on the Country Hydromet Diagnostics methodology, which provides a high-level strategic assessment on the maturity level of the Bangladesh Meteorological Department across 10 elements through a peer-review process.

The benefits of hydromet services lie in their use by different sectors. Better observation of weather and water, enhanced models, and improved forecasts only yield socioeconomic benefits when they inform decision-making. As such, close collaboration with agriculture, water resource, energy, health, and other sectoral agencies is required to tailor forecasts and additional messaging to user needs and enable actions that avoid damages and losses from extreme events or increase efficiency and production.

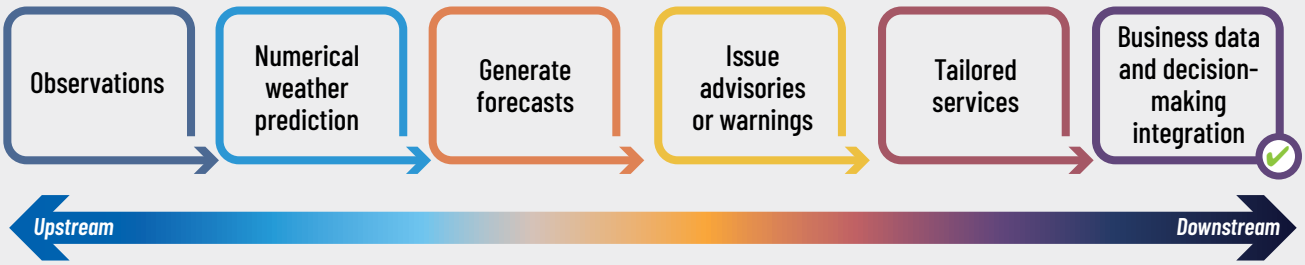
Program

The government of Bangladesh initiated the Bangladesh Weather and Climate Services Regional Project in 2016, supported by the World Bank. The project offered an innovative end-to-end solution that covered upstream, midstream, and downstream parts of the hydromet services value chain (figure 25), including: building and upgrading observation networks; improving forecast quality and modeling capacity; enhancing tailored early warning and advisory services and tools; building technical capacity across the entire value chain; and enhancing collaboration between the Bangladesh Meteorological Department (BMD), Bangladesh Water Development Board (BWDB), and Department of Agricultural Extension (DAE). Through coproduction between these three agencies, the forecasts are converted into tailored and actionable information that farmers can use to support their decisions along the crop cycle.

The project modernized the country's hydromet observation network, computing capabilities, data management, and models. It installed more than 600 meteorological stations—including 35 synoptic automatic weather stations, 285 agricultural automatic weather stations, and 330 automatic rain gauges—and more than 1,000 hydrology stations, including 905 automatic groundwater stations, 315 surface water monitoring stations, and 40 coastal water level measurement instruments. This was accompanied by improvements in computing power, data management, forecasting, and modeling capacity, as well as hands-on operations and maintenance (O&M), weather forecasting, and flood forecasting training.

The project also established agrometeorological services. This included developing processes to convert meteorological and hydrological forecasts into information that is relevant for farmers, establishing the Bangladesh Agrometeorological Information System (BAMIS), issuing advisories before extreme events, and setting up mechanisms to disseminate information to farmers, particularly in rural areas, such as agromet kiosks, digital display boards, community radio stations, farmer groups, and short message services (SMS).

FIGURE 25. GENERIC VALUE CHAIN OF HYDROMET SERVICES



The project design incorporated institutional strengthening interventions to improve climate and weather service delivery. For example, it ran more than 40 seminar and conference programs in several districts to improve the technical capacity of field office staff, and established meteorology degrees in one university and agromet departments with associated degree courses in two agricultural universities, to ensure a more sustainable medium and long-term supply of technical experts within the country. It also promoted applied research for the DAE in collaboration with four agricultural research institutes. To enhance multiagency coordination and achieve the most effective use of hydromet services for the country and its people, a memorandum of understanding between the BMD, BWDB, and DAE is being finalized that will ensure the seamless sharing of real-time data.

Results

Enhancements in observation, computing capability, and models resulted in enhanced forecasting skills. The BMD was able to significantly improve its weather forecasts by moving from a one-day forecast with a three-day outlook to a three-day forecast with a five-day outlook, moving from 9- to 3-kilometer resolution, running two models a day (instead of one) to update the forecasts more frequently, and establishing longer-term subseasonal and seasonal forecasts (from 10-day ones to several weeks) in collaboration with the DAE. The BWDB also enhanced its flood forecasting capabilities from 31 districts to all of the country's 64 districts. These enhancements provide more accurate, localized information—including under unstable conditions related to extreme events—improving people's ability to plan and prepare.

Establishing agrometeorological services helps translate forecasts into actionable advisories for farmers. The DAE now prepares weekly agromet bulletins that are tailored to farmer's needs, providing the weather forecast (temperature, precipitation) and actionable advice. This includes the best timing for planting or applying fertilizer or pesticide, land water levels to be maintained, and species-specific steps for combatting pests. It also prepares advisories ahead of extreme weather events. For example, before Cyclone Mocha in 2024, the DAE advised farmers to harvest rice that was above 80 percent maturity and mangos and other crops that were close to maturity, and to protect fishponds with netting. The project has also developed multiple mechanisms to disseminate advisories and other information, with BAMIS at its core. The BAMIS portal, which gives the whole country access to actionable information, has had more than 6.8 million views since going live in 2019. Agromet display boards and kiosks at DAE extension offices across the country have given farmers key information and access to BAMIS, and around 30,000 lead farmers from 15,000 farmers' groups receive agromet information through SMS and voice messages.

Better weather forecasting is proven to significantly reduce weather-induced crop losses in Bangladesh. Combining household surveys with high-resolution reanalyzed and weather station-based climatic and weather data, and using empirical methods, one study found that increased accuracy of weather forecasts in the country has reduced reported crop losses among farmers (Dasgupta and Robinson, forthcoming), with a 3.3-percentage-point difference (from 4.11 percent reduced to 0.82 percent) between the least and most accurate weather forecasts. It also found that larger farms benefit more than medium-sized farms from improved and accurate forecasts, and that benefits extend beyond the agricultural sector, with timely early warning systems playing a crucial role in saving lives when disasters occur.

Weather station monitoring equipement. Credit: © AdrianHancu/ istock.com

Key takeaways

An end-to-end approach impacts the entire hydromet service value chain. This comprehensive strategy not only fully modernizes the foundational elements, such as hydromet observations and instruments; it also addresses sector-specific elements along the entire downstream value chain. In the past, many hydromet modernization projects focused solely on strengthening hydromet service providers and did not tailor the services to different sectors. But there is no reason to wait until the hydromet services have been fully modernized to work with sectors. This needs to happen in parallel, because the value of hydromet services can only be demonstrated when better decisions are made, due to having access to better hydromet information, resulting in tangible economic benefits. From a political economy perspective, this is crucial to ensure enough O&M budgets for the modernized system and ongoing investments. Interaction with sectoral users will also allow hydromet service providers to better understand and tailor their products to meet sector needs. The collaborative approach taken by the BMD, BWD, and DAE in developing agromet services under this project can serve as an example for designing other hydromet modernization initiatives.

Longer-term sustainability remains a significant challenge in terms of maintaining and continuously enhancing a country's hydromet capacity. There are three dimensions to this challenge. First, financial sustainability is crucial, as advanced climate and weather observation infrastructure and equipment require substantial O&M costs. Second, sustainable, modernized systems require recurring investment to ensure the timely replacement of infrastructure and equipment as they approach the end of their lifecycles. This is often not well enough understood, and securing the necessary funds and logistical support for these updates can be uncertain, particularly if equipment is damaged before its planned replacement. The concepts of fit-for-purpose and fit-for-budget hydromet services, as well as total cost of ownership, can help address these financial and technical sustainability challenges (Grimes et al. 2022). Finally, human resource sustainability is a concern, given the highly specialized nature of the hydromet field. Ensuring a constant supply of technically competent staff should be part of a country's hydromet development strategy.

3.2.2. Programmatic, regional solutions for resilient transport in Pacific Island countries (PICs)

Transport networks in PICs are highly vulnerable to natural hazards, largely due to a lack of climate-resilient design standards, insufficient maintenance, limited network redundancy, and institutional capacity constraints. In Fiji, Tropical Cyclone Winston in 2016 caused estimated losses of more than 120 percent of GDP, with 61 percent of infrastructure damage costs in the transport sector. Many PICs have limited fiscal space for infrastructure capital investment and maintenance, further exacerbating this vulnerability.

Program

With support from the World Bank, six PICs are implementing the Pacific Climate Resilient Transport Program (PCRTP) to drive a climate-resilient transport lifecycle framework in the region. This framework provides an opportunity to integrate climate risks and resilience in a holistic and systematic manner into transport systems, starting in the planning stage, and continuing through infrastructure design and construction, O&M, continency planning, and institutional capacity and coordination (figure 26). There are eight PCRTP projects in six countries—the Federated States of Micronesia, Kiribati, Samoa, Tonga, Tuvalu, and Vanuatu—and another is under preparation in Fiji.

The PCRTP is mainstreaming climate considerations in transport projects in PICs through investments and technical assistance in all segments of the transport infrastructure lifecycle. It has initiated a shift in climate adaptation from a reactive to a proactive approach, through greater focus on systems planning, contingency programming, and related institutional strengthening and coordination measures. The program has four main components (World Bank 2024c):

- **Spatial and sector planning**, which involves integrated climate vulnerability assessments at project site and transport network levels that consider current and future climate risks, developing climate-informed transport network strategies and master plans, and deploying climate-informed asset and safety management systems
- **Climate-resilient infrastructure solutions**, which include adopting climate-resilient design standards for rehabilitating and building transport infrastructure and drainage structures, and deploying engineering, hybrid, and NbS as protective measures; the latter are integral to project design and finance, and include planting mangroves, trees, and other local vegetation

▲ **Extreme wind on a beach in Fiji during Cyclone Sarai. Credit: © Kaszojad/istock.com**

Fiji Red Cross disaster preparedness station. Credit: © chameleonseye/ istock.com

for coastal storm surge protection and to improve slope stability near roads

- **An enabling environment**, which provides technical assistance for legal and regulatory reforms, developing climate-resilient design and construction standards, investing in institutional capacity building through awareness-raising, training, studies, and by establishing information systems to collect, organize, store, and analyze climate and natural hazard data
- **Disaster preparedness and postdisaster recovery**, which develops emergency preparedness and response action plans, establishes quick-disbursing financing mechanisms and cross-government and donor coordination for emergency relief, and supports postdisaster needs assessments and urgent works, such as infrastructure repairs.

Results

The PCRTP is already showing results. This includes increased climate resilience in 11.2 kilometers of primary road, one airport, and two wharves in Samoa and Tonga. By 2030, the program expects to enhance the climate resilience of at least another 140 kilometers of roads, 10 bridges, and 6 maritime ports in the seven project countries, benefiting over 60 percent of their populations.

Such investments are expected to yield significant benefits in reduced maintenance expenditure and avoided disaster damage. The road network rehabilitation on Samoa's Upolu and Savai'i islands shows that upgrading vulnerable parts of a network to meet climate-resilient design standards costs an estimated $0.16 million per kilometer, compared to the $0.20 million per kilometer needed for basic repairs without the higher design standard. Enhancing the climate resilience of the entire road network will cost around $53 million for

some 330 kilometers of vulnerable roads and crossings; but it should also reduce maintenance expenditure by 20 percent and postdisaster rehabilitation costs by 75 percent, and local communities will avoid earning losses due to connectivity disruptions. The climate-resilient road network will reduce repair and restoration costs from an estimated $200,000 to $50,000 per kilometer, assuming stabilized slopes lead to an absence of landslides and improved drainage and stronger pavements reduce asset damage and washout.

PICs have endorsed and accepted the transport infrastructure lifecycle approach. For example, Samoa's Cabinet Development Committee endorsed the program's vulnerability assessment and climate-resilient road strategy, leading to a marked shift from an ad hoc approach to road upgrade selection to vulnerability-based prioritization of investments. The government of the Federated States of Micronesia approved a comprehensive climate-resilient road strategy to identify priority road segments for investment, as well as recommendations for policy reform, a climate-informed road asset management system, and maintenance practices.

The PCRTP's regional, programmatic approach has reduced transaction costs and improved management efficiency. The program enables more efficient project preparation and implementation by using standardized templates for project development, results framework indicators, terms of reference for contractual work, and data collection for systems planning, project design, and asset management systems. Informal and formal knowledge exchange helps or will help share lessons learned across projects, provide data and process benchmarks for new projects, and fill gaps when in-country data are unavailable.

PICs have used innovative, locally appropriate construction technologies and materials to promote resilience. Using locally available construction materials, such as concrete masonry block revetments or "besser blocks", helps overcome challenges related to high

Coastal road in the South Pacific island of Tonga. Credit: © dane-mo/istock.com

import costs of construction materials and ensures infrastructure is fit for purpose and adjusted to the local context and climate conditions.

Key takeaways

Countries can optimize resilience by addressing climate risks through interventions that span the transport infrastructure lifecycle, adopting programmatic approaches where feasible. Combining measures generates higher benefits than deploying measures in isolation. In countries where resources and capacity are constrained, a regional, programmatic approach generates benefits across projects by improving management efficiency, reducing transaction costs, and sharing data and lessons learned across and within countries.

A mix of fit-for-purpose, cost-effective, and resilient engineering designs, locally appropriate construction materials for hard infrastructure, and complementary NbS generate higher benefits and network performance. This requires transport design standards and asset construction, rehabilitation, and upgrades to consider of current and future climate risks and local contexts. Inclusive stakeholder consultation and citizen engagement will help identify and deploy suitable climate risk reduction measures and maximize socioeconomic benefits, while adopting hybrid engineering solutions and NbS using locally appropriate materials and practices will lower costs and provide multiple benefits to local communities. Undertaking a multicriteria analysis that considers technical, financial, implementation feasibility, social acceptance, and operational suitability can help define the right balance between traditional engineering solutions and NbS.

Leveraging new technologies, open data, and innovative tools can help PICs shift from a reactive to a proactive approach to climate resilience and mainstream climate resilience in transport projects. Experience in PICs shows that investing in spatial and sector planning—through climate risk assessments, climate-informed asset management systems, climate-resilient transport strategies, and so on—can inform and prioritize climate-resilient investment plans, support efficient public investment, crowd in resources from the international donor community, and avoid expenditure duplication. Developing these planning tools as dynamic instruments that are regularly updated can equip government decision-makers to address risks with the most accurate information and tools available. Technological innovations can offer low-cost opportunities for data collection, enabling the regular update of asset inventories and spatial analysis to improve stakeholders' understanding of climate risks. Using open-source interoperable tools can also facilitate cross-agency collaboration.

Strengthening technical and managerial capacity in transport agencies is essential for the sustainability of climate-resilient transport networks. The pursuit of climate-resilient transport is a complex multidisciplinary undertaking that requires strong institutions across numerous sectors. To support a robust enabling environment, building capacity through technical assistance and training to facilitate institutional, legal, and regulatory reform, establishing mechanisms for inter-agency and departmental coordination, and creating technical roles to support resilience are all key. When technical and management capacity is too low or staff turnover too high to effectively deploy and manage resilient transport networks, government capacity can be supplemented with external specialized expertise, through consultancy assignments.

3.2.3. Infrastructure investment to build drought resilience in Brazil

A man walks on a dry road in a Brazilian semi-arid region. Credit: © Zé Barretta/istock.com

Brazil's semi-arid northeast, the driest tropical area in the world, faces significant climate and development challenges. Home to approximately 22 million people, or about 12 percent of the population, the region experiences irregular rainfall, poor soil water retention, and severe drought. It lags other regions in Brazil in health, education, and other social indicators, and has the highest concentration of rural poverty in Latin America. Around 67 percent of rural households lack access to the water supply network, depending instead on unreliable water sources, such as small ponds and reservoirs that are susceptible to pathogen contamination, and government-sponsored water tankers during extended dry periods (Da Mata et al. 2023).

Water shortage—a main source of vulnerability for rural households—is exacerbated by the changing climate. This leads to greater uncertainty in water availability and an increased frequency of extreme water stress episodes. High evapotranspiration rates and the region's geology also complicate water retention, as the rocky, shallow soils have low water retention capacity. Groundwater wells, which often yield water with high salinity levels, cannot meet the region's needs.

Program

The First Water Cisterns (FWC) program supports a shift from relief and response efforts to fostering sustainable coexistence with drought conditions. It was launched with the goal of building resilience among the most impoverished families in the face of growing water stress. In 2003, local civil society groups, churches, and unions developed the One Million Cisterns Program (P1MC), an umbrella program that includes the FWC and was implemented through partnership agreements with Articulação Semiárido Brasileiro (ASA), a network of civil society organizations, the Ministry of Social Development, municipal governments, and other partners. The federal government adopted P1MC in the same year, making it a key component of its new zero hunger strategy. In 2013, a law on the National Program to Support Rainwater Harvesting and Other Social Technologies for Access to Water formalized the

program and streamlined its delivery. Initially supported by international NGOs and donors, it was later financed through the federal budget. Since 2003, total investment in P1MC has been estimated at over R$1.1 billion (more than $200 million).[70]

Designed to provide reliable, clean water to rural households, FWC had built 1 million cisterns in the semi-arid northeast by the end of 2014. These tanks facilitate small-scale, decentralized rainfall harvesting using simple, low-cost, and easily scalable technology. Collecting water during the rainy season from gutters installed on roofs, each tank has a standard storage capacity of 16,000 liters, providing enough water for domestic use (drinking and cooking) for a household of five during the eight-month dry season. To ensure the quality of the tank water, families also received training on point-of-use disinfection and essential maintenance steps.

Beyond the FWC program, P1MC has three other components:

- **Water for production:** Introducing systems for FWC families to capture and store rainwater for use in agriculture, vegetable gardens, and small livestock
- **Cisterns for schools:** Building cisterns to collect and store rainwater for drinking and vegetable gardens in municipal schools
- **Seeds for semi-arid regions**: Enhancing, supporting, and establishing seed stores and banks.

ASA selected program beneficiaries through local committees, based on criteria predefined by the federal government. To be eligible, rural households without regular access to water had to register in the national social program registry, and priority was given to those with low income, female household heads, a large number of school- or preschool-aged children, members with disabilities, and elderly members (Da Mata et al. 2023).

Results

Between 2003 and 2016, the FWC program built 1.2 million household water tanks, benefiting 4.5 million people. Under the other components, P1MC also built 200,000 tanks for production, and nearly 5,000 cisterns for rural schools.

The program's impacts extend far beyond its primary goal of improving water availability, also delivering significant development, gender equality, health, and education benefits. Improved water collection systems have been shown to limit waterborne diseases in children and reduce school absences. Specifically, they decreased the risk of diarrhea episodes by 73 percent compared to homes without cisterns (Luna 2011), and increased school attendance by 7.5 percent (Gaiger Silveira et al. 2016).[71] The program also promotes gender equality by registering cisterns in the name of the female head of the household and eliminating the need for women to walk long distances—an average of two hours per day—to fetch water. This gives women more time to engage in community activities, learn new skills, and participate in farming, increasing their independence and income, and enhancing their families' food security (Ferreira Jacques de Moraes and Rocha 2013).[72]

[70] https://d3n8a8pro7vhmx.cloudfront.net/eurodad/pages/2581/attachments/original/1642155880/case-study-brazil-SP-jan04.pdf?1642155880#:~:text=El%20Programa%20Un%20Mill%C3%B3n%20de%20Cisternas%20de%20Brasil%20(P1MC)%20es,lo%20incorpor%C3%B3%20como%20pol%C3%ADtica%20p%C3%BAblica.

[71] https://www.febraban.org.br/7Rof7SWg6qmyvwJcFwF7I0aSDf9jyV/sitefebraban/Apresenta%E7%E3o%20Naercio%20Menezes%20-%20avalia%E7%E3o-P1MC.pdf.

[72] http://genderandwater.org/en/gwa-products/knowledge-on-gender-and-water/articles-in-source-bulletin/brazil-rainwater-harvesting-in-semi-arid-region-helps-women-1.

The program's benefits in birthweight and neonatal outcomes can lead to positive labor market outcomes. An analysis using microdata from over 4,700 pregnant women in the FWC program found that each additional week of exposure to cisterns during the first 16 weeks of pregnancy is associated with a 1.4–1.5-gram increase in the baby's birth weight (Da Mata et al. 2023). A crucial indicator of initial health levels, birth weight is linked to long-term outcomes such as intelligence and education, which in turn translate into positive labor market outcomes, such as employment and earnings. The program's benefits are estimated to yield around $14 in increased labor market returns for every additional gram of birth weight, resulting in a net gain of approximately $200 per cistern installed (Da Mata et al. 2023). The program was also found to have a positive causal effect on employability and wages, increasing the probability of employment and average salary by 14 and 7.5 percent, respectively, compared to the period before program implementation (Britto, Carrillo and Sampaio 2021).

Beyond individual benefits, the FWC interventions have been found to reduce political clientelism by decreasing the dependence of vulnerable populations on local political patrons. This has led to improvements in political accountability and governance, as beneficiaries were less likely to exchange votes for favors (Bobonis et al. 2022).

Key takeaways

Promoting decentralized technologies and services can improve water availability and water quality in households. This is true, regardless of prevailing sanitary conditions or policy responses to aggregate climate shocks.

Shifting from drought relief and response to building sustainable interventions can enable coexistence with drought. This is especially important when it comes to designing further climate adaptation initiatives, which need to balance the incorporation of emergency preparedness along with strengthening resilience and coexistence with different climate scenarios.

It is important to consider "last mile" effects and take necessary provisions to address any challenges. The FWC shows stronger positive effects for more educated women, who are more likely to comply with the program's training on water cistern management. Addressing bottlenecks to ensure similar impacts for women with lower education levels would extend the benefits of the program to a broader population—a point to consider when implementing interventions in areas where precarious living conditions and low beneficiary education levels could impose a major challenge to overall program effectiveness (Gomes, Heller and Pena 2012). Improved information about potential beneficiaries and continued monitoring of their adoption of, and compliance with, program objectives can help identify "last mile" challenges.

In a context of high poverty and low access to essential services, large-scale interventions can have considerable and positive effects beyond those initially foreseen. As well as direct improvements to health, providing reliable access to clean water had a positive effect on employment, wages, individuals' time allocation, and political clientelism. These impacts can also generate intergenerational consequences, by reducing crime, increasing women's labor participation, and expanding economic dynamics in small towns, creating positive spillovers to society.

3.2.4. Creating an enabling environment to mobilize private investment: diversifying energy supply in Albania

Komani hydroelectric dam in northern Albania. Credit: © Bardhok Ndoji/ istock.com

Albania's energy sector relies heavily on hydropower, which represents more than 95 percent of the country's electricity capacity. Approximately 90 percent is generated from the River Drin. As of 2018, the country's total installed hydropower capacity accounted for just under half (47 percent) of its estimated hydro potential. But this over-reliance on hydropower has left Albania vulnerable to climate variability—especially changing rainfall patterns and drought—and energy shortages, particularly in dry years, forcing it to import electricity to meet demand. In 2017, for example, when rainfall was low, the country had to import nearly 40 percent of its electricity, at a cost of $240 million. Albania's annual energy demand is projected to increase by 77 percent by 2030 compared to 2018, exacerbating the energy deficit challenges.

Climate change is already having an adverse effect on hydropower infrastructure and production, and the impacts are expected to worsen with temperature increase and more extreme events. Climate change will result in increased temperature, lower rainfall, and more frequent and intense extreme floods and droughts in Albania (World Bank Group 2021a). Precipitation is expected to decrease by 10.9 and 13.5 percent by 2050 and 2100, respectively, and as result, annual average electricity output from Albania's large hydropower plants could be 15–20 percent lower in 2050 than 2010 levels (Government of Albania 2022; IRENA 2021). Meanwhile, heavy rainfall events and floods will likely damage hydroelectricity infrastructure and reduce dam storage due to sediments from flooding and erosion.

Program

To address Albania's reliance on hydropower and adapt to the risks of climate change, the government is diversifying the country's energy sources, focusing on non-hydro renewable energy. This is a priority adaptation strategy in Albania's NDC (Government of Albania 2022) and part of a broader national strategy to transform its energy sector from net importer to net exporter (RTI International 2018). Solar energy is expected to play a crucial role in the energy transition, with government plans to increase solar photovoltaic (PV) capacity from 15 to 450 megawatts (MW) between 2021 and 2030. The National Energy Sector Strategy for 2030 envisions a regional integrated and diversified energy system based on market principles and sustainability, with energy imports reduced by 32 percent compared to a baseline scenario.

Albania's first large-scale solar PV project, the Karavasta Solar Project, is expected to significantly contribute to the diversification and resilience of the power sector. With 140 MW of installed capacity and a new 19-kilometer overhead transmission line, this project will not

only help diversify the country's energy mix; it will also demonstrate the viability of solar energy in reducing its reliance on climate-vulnerable hydropower. The project's development, construction, and operation will be funded by a $43.3 million International Finance Corporation (IFC) loan, and financial projections, based on conservative estimates, show a 90 percent probability of exceeding power generation assumptions. Over the loan life, blended revenue is expected to approximate €49 per MW-hour, while the debt service coverage ratio will vary, depending on the power sale structure, ensuring the project's financial sustainability.

Results

The project is designed to withstand the impacts of climate change—particularly inland and coastal flooding—and increase household and community resilience. To enhance its operational resilience, it will install solar panels above predicted flood levels, allocating $630,000 for these climate-proofing efforts. As well as contributing to its NDC adaptation priority of climate-proofing energy infrastructure, the project provide electricity to more than 66,000 households and create new jobs.

It will also contribute to climate mitigation by replacing imported fossil fuel energy. Though Albania's power sector is not a large producer of GHG emissions, most of the electricity it imports from neighboring countries is fossil fuel based. The project will help reduce annual GHG emissions by an estimated 68,032 metric tons of carbon dioxide equivalent against the counterfactual, based on partially fossil fuel-based imported power generation.

Project implementation will closely track key outcomes throughout the life of the project. Indicators to measure these outcomes can include annual generation, GHG emissions reductions, share of non-hydro renewable energy supply, job creation with gender disaggregation, and number of privately financed renewable energy projects under power purchase agreements.

Key takeaways

The dominance and inefficiency of the public sector pose a challenge to the project. Albania's energy sector is owned by the state, and 60 percent of generation and 100 percent of transmission, distribution, and supply are managed by public entities. Inefficiencies within this framework make energy prices largely dependent on international trade and market conditions, creating uncertainties. But the project's hybrid commercialization framework—which combines a fixed tariff for 50 percent of production and market-based sales for the other 50 percent—mitigates this risk and sets a model for future private sector participation.

Support from the Albanian government has been crucial. The 30-year Project Development Agreement with the Ministry of Infrastructure and Energy provides land rights, compensation for adverse law changes, and guarantees for termination payments in case of breaches, ensuring bankability and investor confidence.

Mobilizing finance is important for large-scale renewable energy projects. The IFC, European Bank for Reconstruction and Development, and commercial lenders have played a key role in providing the necessary long-term financing under challenging market conditions. As the first large-scale solar PV investment awarded through a competitive auction in Albania, the Karavasta Solar Project is expected to demonstrate the bankability of Albania's regulatory framework and set a precedent for future private-sector investments in renewable energy. This successful mobilization of financing offers a replicable model for other countries seeking to diversify their energy sources while enhancing climate resilience.

3.2.5. Adaptive social protection to support poor and vulnerable people in Bangladesh, Nigeria, Nepal, and Niger

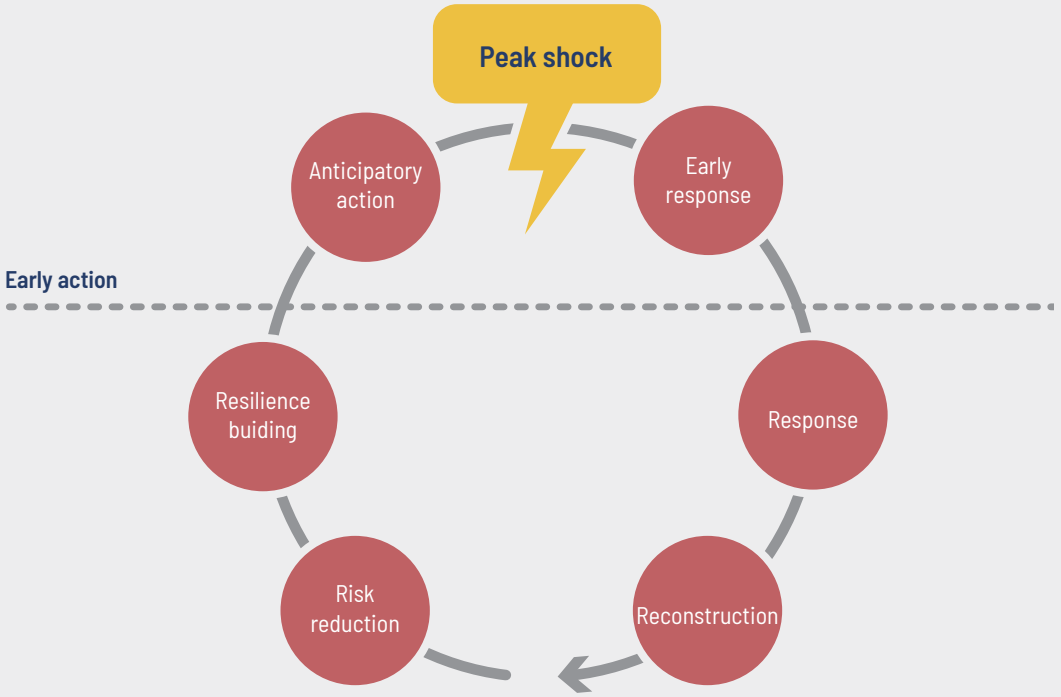
Two women spinning wool in Bhaktapur, Nepal. Credit: © hadynyah/ istock.com

Early action is a recent innovation that aims to deliver faster short-term support to households in response to crises and offers valuable lessons for shock-responsive or adaptive social protection systems. Humanitarian assistance often reaches households after a shock has caused significant damage and suffering, mostly due to the need to conduct a needs assessment before mobilizing funds and making allocation decisions. Recent advances in forecasting and remote sensing data have made it possible to anticipate or monitor in real-time extreme weather events at a relatively granular level and with enough lead time to enable an earlier response to shocks so that they do not become a humanitarian crisis. The case studies in this section, backed by rigorous impact evaluations, showcase growing evidence that the timing of the delivery of cash transfers matters for household welfare and can improve the effectiveness of short-term crisis response by ensuring that people do not fall into (deeper) poverty.

The approach

There are two forms of early action: anticipatory action and early response, which sit along a continuum. By acting in advance of predicted hazards, *anticipatory action* aims to prevent or reduce the adverse effects of shocks on lives and livelihoods before the impacts fully manifest (Scott 2022). *Early response*, on the other hand, delivers support to affected households much earlier than a traditional humanitarian response, but not necessarily before the hazard fully materializes—for example, through rapid response programs that are implemented in the immediate aftermath of a shock or crisis. An early response may be more appropriate in contexts where it is difficult to forecast or anticipate a given shock or may form part of a stepwise approach away from a traditional humanitarian response towards early action. Situated on a continuum of policy options (figure 27), both approaches aim to deliver assistance when it can have the greater impact

FIGURE 27. EARLY ACTION AS PART OF THE RESILIENCE AND RESPONSE CONTINUUM



in mitigating the effects of a shock on affected populations.

The following elements need to be prearranged for effective early action:

- **Financing**: A defined amount of funding is secured and agreed in advance to address an estimated need and can be released quickly in the event of a shock.
- **Triggers**: Decision rules or triggers decide when and where a hazardous event will occur (or has occurred) and therefore when and where to act—including by releasing prearranged funding—which reduces the time taken to assess the situation and make decisions, speeding up response times. Basing these rules on forecasts and predictive analytics further advances the response, enabling action before the impacts of a shock materialize or even before the shock occurs. Trigger quality can vary substantially across different contexts for the same hazard type, and their effectiveness depends on the availability of high-quality data and accurate forecasting models.
- **Action plan**: Developing a comprehensive plan in advance that outlines specific measures to be implemented when the triggers are met helps support the most critical needs and decisions of affected households at the time of the response, which is context- and hazard-dependent. For example, providing cash before a flood happens expands a household's choices about how to best prepare for the flood, whether by stocking up on food or evacuating livestock. Providing cash immediately after a flood allows households to invest in recovery without taking on high-interest debt or removing children from school, which both have longer-term consequences on poverty. An action plan should clearly define eligibility criteria,

targeting modalities, and payment methods to ensure that support swiftly reaches the most vulnerable and affected populations. It should also include the estimated number of people to be reached, the extent of support, and options for surge capacity if staffing and other resources are deemed to be insufficient.

- **Monitoring, evaluation, and learning:** Continuous learning and refinement through sound monitoring and evaluation add an essential fourth ingredient for successfully scaling up early action.

Anticipatory action is being rapidly scaled up within the humanitarian sector, primarily driven by the UN and NGOs. A global overview of anticipatory action found that in 2023, 107 anticipatory action plans or frameworks were in place across 47 countries, covering an estimated 10.9 million people and $148 million in prearranged financing, and another 133 frameworks were under development in 68 countries, targeting 19 hazards (Anticipation Hub 2024). Drought is the most common hazard in terms of number of people protected, followed by multihazard events, floods, and storms, and the most common anticipatory actions to help households prepare for shocks are cash and voucher assistance; water, sanitation, and hygiene interventions; and agriculture- and livestock-related activities. Although the UN and NGOs are the main drivers of these frameworks, they typically rely on government data for trigger design and are often integrated into national response plans. Mozambique serves as an example of how to embed anticipatory action within national processes and tools, as its government, through the National Institute for Disaster Management and Risk Reduction, led a technical working group in 2023 to coordinate an anticipatory action response to drought.

At the same time, governments are increasingly using their social protection systems to provide timely support to vulnerable populations in response to shocks, including a shift towards early action. This was clearest during the COVID-19 pandemic, when social protection systems and labor market measures increased fivefold globally between May 2020 and January 2022, resulting in substantial coverage and effective outreach to the poor (Gentilini et al. 2022). Governments have used similar programs to respond to droughts (Kenya, Malawi, Niger, and Uganda), flooding (Pakistan and Senegal), typhoons (the Philippines), and hurricanes (the Caribbean). Building a shock-responsive cash transfer program mirrors investments in early action, but within government systems, with humanitarian actors stepping in only when capacity is overwhelmed. This approach requires governments to maintain and potentially increase cash transfers to chronically poor households in affected areas during a crisis, while also expanding the coverage of these programs to additional households in need of support. Disaster risk and contingent financing tools—such as the World Bank's Catastrophe Deferred Drawdown Option (Cat DDO) (World Bank 2024b), sovereign risk, and parametric insurance—have provided the financing to governments to deliver timely assistance through their social protection systems. But getting money out to affected populations quickly remains a challenge, underscoring the promise of early action.

Results

Early action programs, including through national safety net programs, have helped alleviate short-term humanitarian need by reducing food insecurity. The case studies outlined here, backed by rigorous impact

evaluations using randomized control trials or quasi-experimental approaches, demonstrate the value of early interventions. They all find that positive benefits accrue in the days, weeks, or even months before a conventional humanitarian response. But, although all the studies demonstrate the potential of anticipatory and early response cash transfers to help households cope with shocks in the short term, they also highlight the need for complementary interventions to build longer-term resilience in climate-vulnerable communities.

Anticipatory action for floods in Bangladesh

In July 2020, the World Food Programme used a two-stage trigger based on forecasts of upstream water flow to send BDT 4,500 (equivalent to two weeks' household food expenditure) via mobile money to more than 23,000 ultra-poor households predicted to experience a 1-in-5-year flooding event along the Jamuna River in northern Bangladesh. The first trigger initiated preparations 10 days before the predicted flood, and the second released cash transfers funded by the UN Central Emergency Response Fund to affected households five days before the flood peak; this was 100 days earlier than previous interventions. These anticipatory cash transfers were part of a broader UN pilot, with the Food and Agriculture Organization and UN Population Fund delivering their own anticipatory action interventions in response to the trigger activation. As noted above, these actions were predefined in a plan, which outlined both the triggers and prearranged financing mechanisms.

A quasi-experimental evaluation comparing households that received anticipatory cash with those that received nothing due to not having the correct mobile money wallet found that the cash improved welfare during—and up to three months after—the flood. For instance, children in recipient households were 3.8 percent more likely to consume three meals or more on the day before the survey three months later. This result is striking, given the evidence on long-term consequences of temporary child undernutrition. The cash transfers mitigated both the flood impacts on subjective well-being (with recipient households reporting 18.7 percent higher life satisfaction) and asset loss (by 0.1 standard deviations relative to the control group). Recipient households also showed signs of early recovery: they were 7.8 percent more likely to report having avoided crop loss or being able to replant. There is evidence to suggest that the timing of the anticipatory cash transfer increased the choices available to households before the flood, enabling them to take more pre-emptive measures (Pople et al. 2024a). Receiving cash one day earlier relative to the flood peak also improved welfare.

Comparing early action and post-flood cash transfers in Nigeria and Nepal

Two randomized control trials in Nigeria and Nepal evaluating the impact of early action and post-flood responses in mitigating the effects of severe flooding on vulnerable communities found that early cash transfers had immediate benefits.

In flood-prone northeastern Nigeria, the International Rescue Committee piloted an anticipatory cash transfer program using satellite-based triggers in 2022. Upon trigger activation, the pilot delivered 195,000 Naira (around $400) to 725 households before the flooding took place, while 725 control households received post-shock transfers. The study showed reduced negative coping strategies, increased preemptive actions, and improved labor reallocation decisions, but no significant effects on short-term food consumption or subjective well-being (Balana et al. 2023).

A similar World Food Programme pilot in Nepal provided an unconditional cash transfer of

Flooded roads as a result of the overflowing of the Alau dam, Nigeria. Credit: © Sadiqnanic/istock.com

15,000 NPR (approximately $111) and early warnings to a randomly selected group of vulnerable households shortly after the flood forecasts were triggered. This early response reached households immediately after the flood peak. Compared to households that received a similarly sized cash transfer two months after the flood (the traditional humanitarian response), those that received the earlier transfer were 8 percentage points more likely to achieve acceptable levels of food security. They also reported improved mental health, with an increase of 0.13 standard deviations relative to the control group. In the medium term, more flood-affected households receiving early transfers showed higher agricultural spending and revenue (Balantrapu et al. 2023).

Both studies found convergence of effects between early action and post-flood groups, on average, over time and limited long-term effects on assets or other labor market outcomes, including nonagricultural activities. This suggests that early action primarily buffers immediate impacts on food security and well-being.

An early response to drought in Niger

The government of Niger, one of the world's most climate-vulnerable countries, implemented an early social protection response to drought using satellite-based triggers in 2022. The program delivered four large cash transfers before the lean season, beginning four months earlier than traditional humanitarian assistance, which is typically provided during peak food insecurity. A randomized control trial was conducted to evaluate the impact of varying the timing and size of cash transfers. Comparing three modalities—four large transfers before the lean season, four large transfers during the lean season (the traditional response), and 12 smaller, regular transfers delivered before the lean season and continuing throughout the year—the study found that the early cash transfers yield the greatest welfare benefits overall. Compared to the traditional response, the early transfers improve food security, consumption,

and psychological well-being by 8, 17.6, and 17.8 percent, respectively, before the lean season, and have sustained effects during the lean season. The smaller, regular transfers have more modest impacts and show no clear benefits over the traditional response. The timing of transfers shifts financial behaviors, particularly borrowing, but has limited impact on livelihoods. Beyond the lean season, welfare effects converge across modalities, suggesting that the timing and size of cash transfers do not have differential medium-term effects, although the study cannot speak to the impact of cash transfers in general. These findings demonstrate the value of large enough early transfers in supporting consumption smoothing and mitigating the impacts of a severe drought (Pople et al. 2024b).

Key takeaways

In the short term, anticipatory action and early response are more effective than a traditional, ex post response in helping households smooth their consumption in response to an extreme weather event.

Effective anticipatory action and early response build on existing social protection systems and procedures to enable scale-up and rapid expansion once the response is triggered. Investing in the following areas will help ensure safety net systems are responsive to extreme weather events:

- **Coverage,** to reach a significant share of vulnerable populations, as the provision of regular safety net support reduces the vulnerability of poor households to shocks, while delivery systems that underpin these programs provide a strong foundation to support the rapid delivery of an early response.
- **Outreach and targeting,** to rapidly identify vulnerable and affected populations. Countries can use various targeting methods to identify vulnerable households, alongside active outreach and communication strategies to ensure they reach all eligible households. Although they can use existing registries developed using proxy means testing or community-based targeting if they are current and have adequate coverage, targeting based on chronic poverty before a shock may not accurately reflect real-time vulnerability to extreme weather events. As such, there is growing interest in new dynamic targeting methods, such as machine learning algorithms and phone data, which are being researched and refined (Aiken et al. 2022).
- **Payment delivery systems,** to send cash transfers to targeted households. The recent shift toward digital payment systems has enabled more rapid cash transfer delivery, which is particularly important in the context of sudden-onset events, such as floods or storms. As governments often use third-party institutions, such as NGOs, for last-mile delivery, having contracts already in place is essential to engage them at short notice when needed.[73]
- **Availability of inputs,** in the case of in-kind support.

Without these pre-established foundations, the response can be severely delayed, even when it is intended to be rapid. For example, in Niger during the 2021–22 drought, the early response was delayed by approximately three months because arrangements for targeting and enrolling beneficiaries were ad hoc, rather than prepared in advance. The government also had to negotiate contracts with providers to deliver emergency payments, which took nearly two

[73] https://blogs.worldbank.org/en/climatechange/tackling-food-insecurity-satellites-and-cash-five-lessons-niger.

months, despite fast-tracking the procurement process. Ensuring such arrangements are made beforehand significantly reduces response times.

Investing in robust hydromet and weather services and capacity building expands the possibility of trigger-based financing for more hazards and across more countries. High-quality data support the development of effective triggers with policy-relevant thresholds for action (Chaves-Gonzalez et al. 2022). Yet forecasting many shocks, such as cyclones or flash flooding, is challenging. Trigger design must balance the need for precise and reliable forecasts against technology limitations, data availability, and the urgency of delivering timely support ahead of a shock. In the context of inaccurate forecasts, expanding anticipatory action may also increase targeting errors, providing aid to unaffected populations. Forecast trigger and context selection should therefore weigh the benefits of early action against potential resource misallocation due to forecast errors.

Putting in place prearranged financing for early action is also challenging, given the historic reliance on humanitarian appeals in some countries, and the need to ensure a sequencing of financial instruments. While prearranging funding ensures a timely response, committing resources based on uncertain risks means that these funds cannot be used for developmental investments, may limit flexibility for other emerging crises, and risks "wasting" funds if anticipated events do not fully materialize. As a result, sequencing the use of a range of prearranged financing instruments is required, with contingency or reserve funds or budget lines being used to fund more frequent (often less severe) events, contingent financing or market-based instruments (such as parametric insurance) for less frequent but more severe events, and humanitarian financing as a last resort option. Ensuring that these instruments are sequenced in a manner that ensures continuity and coherence to shocks of varying magnitude is central to maximizing impact and ensuring continued political support for such reforms.

Effective anticipatory action and early response mechanisms require collaboration between the scientists who design the triggers, the policy makers who are willing to act on them, and the implementing partners who deliver the support. Building trust between and ownership among key decision-makers, especially governments, involves close collaboration and transparent communication about tradeoffs inherent in the process and commitments from development partners and humanitarian actors to release funds based on these same triggers.

Finally, early action protects development gains and is most impactful when integrated into comprehensive climate resilience strategies. Integrating these approaches within national response plans from the outset, considering implementation capacity and funding streams, will ensure coherence. They work best as part of a holistic approach that includes recovery and rehabilitation investments to address unmitigated losses and long-term development initiatives that are focused on poverty alleviation.

These case studies illustrate that integrating decision rules and prearranged financing in social protection systems can transform the timeliness of short-term support to vulnerable populations in response to increasingly frequent and severe extreme weather events.

3.2.6. Saving lives through a heat-health action plan in India

Sabarmati riverfront in the city of Ahmedabad, Gujarat in India. Credit: © saiko3p/istock.com

Heat stress is the world's leading cause of weather-related deaths, and cities in India are particularly exposed and vulnerable to heat-related health impacts.[74] Ahmedabad, the largest city in the northwestern state of Gujarat, and home to more than 7 million people, is no exception. Outside of the monsoon months, its climate is characterized by extremely dry and hot weather. Between 2010 and 2019, the highest average maximum daily temperatures for March, April, and May were 40°C, 43°C, and 45°C, respectively, with temperatures reaching an all-time high of 48°C on May 20, 2016 (Mohanty et al. 2022). Heat stress is exacerbated by the urban heat island effect, and despite being already high, temperatures in India are expected to rise due to climate change, especially in the northwest (Mukherjee and Mishra 2018; Chakraborty et al. 2020). In 2010, a heatwave where temperatures reached nearly 47°C caused an additional 1,334 deaths in May alone, a 43 percent increase over the baseline mortality rate (Hess et al. 2018).

After the devastating 2010 heatwave, recognition of heat as a threat to public health grew, and heat preparedness became a priority for the city government. The Ahmedabad Municipal Corporation (AMC) partnered with the Public Health Foundation of India, the Natural Resources Defense Council and a coalition of international partners to develop a heat action plan (HAP) for Ahmedabad. This became the first heat-health action plan implemented in a South Asian city.

Program

The Ahmedabad HAP establishes key measures for both immediate and longer-term actions to reduce the public health impacts of extreme heat. First implemented in 2013, it is evaluated and updated annually. A lead officer appointed by the AMC facilitates its implementation. The HAP includes the following key interventions (Knowlton et al. 2014):

[74] https://gca.org/video/heat-stress-the-silent-killer-in-indian-cities/.

- **Public awareness:** Community outreach is a key adaptation strategy of the HAP, with heatwave risks and practices to prevent heat-related deaths and illnesses communicated through media outlets, orientation materials, and interpersonal communication.
- **An early warning system:** The HAP defines different heat thresholds that trigger certain emergency responses, including alerting residents of predicted temperatures. Formal communication channels have been established to alert health officials, hospitals, emergency responders, and government agencies. The HAP identifies responsibilities for each agency that forms part of a coordinated emergency response. For example, the transport department is advised to install fans in the waiting areas of trains and bus stations, and the AMC lead officer is responsible for providing access to "cooling centers", typically in temples, mosques, or malls.
- **Capacity building among health care professionals:** As part of the HAP, health care professionals, including community health staff, receive training on how to recognize and respond to heat-related illnesses.
- **Reducing heat exposure:** The HAP promotes adaptive measures such as the Cool Roofs Program, which aims to increase the adoption of cool roofs to improve heat resilience while saving energy.

The HAP is underpinned by scientific research. To support the development of the original 2013 HAP, the AMC and its partners conducted research on the excess mortality associated with the devasting 2010 heatwave and on contributing factors to household heat vulnerability, with a focus on slum communities and outdoor workers (Azhar et al. 2014; Knowlton et al. 2014; NRDC 2013). Although it is a citywide plan, identifying and reaching the most vulnerable populations is at the heart of the HAP.

Results

Ex post analysis suggests that the HAP and extreme heat warnings have reduced heat-

Rickshaw driver rides his vehicle under the heat on the street of Old Delhi, India. Credit: © ErmakovaElena/ istock.com

related mortality. In the first two years after implementation (2014–15), it is estimated that 2,380 deaths were avoided in the city (Hess et al. 2018). Death rates on days with maximum temperatures of 47°C used to be more than twice as high as on days with temperatures of 40°C; following the HAP implementation, this reduced to 25 percent.

Ahmedabad's HAP is a leading example of city-led action and a blueprint for heat action planning in South Asia. In 2016, India's National Disaster Management Authority issued national guidelines for preparing heat action plans. The revised guidelines, published in 2019, include a section on past experiences featuring the Ahmedabad HAP as a best practice example (NDMA 2019). The HAP has also been used to guide heat action planning outside of India, including in Nepalgunj, Nepal (Subedi et al. 2022). The AMC and its partners have developed resources to support other cities looking to adapt to extreme heat, including a how-to manual with seven steps to develop a HAP, based on Ahmedabad's experience (AMC et al. 2016).

Key takeaways

Clearly defined roles and responsibilities are imperative for an effective emergency response to extreme heat. A robust emergency response requires coordination and seamless collaboration across multiple departments and stakeholders (Keith et al. 2012), and as such, roles and responsibilities must be clearly outlined (Kim, Henry and Jain 2023). In Ahmedabad, a high-ranking lead officer in the AMC's health department provides leadership and coordinates with relevant departments.

Elevating public awareness about the dangers of heat to public health and making the information accessible are essential elements of the overall strategy to combat heat-related risks. In many tropical regions, there is a tendency to underestimate heat as a significant health concern, necessitating initial efforts to raise awareness about the connection between heat exposure and health outcomes. This is especially important for the most vulnerable communities and populations, who are disproportionately exposed to extreme heat events and have limited resources and coping capacity. Establishing a robust communication strategy is therefore crucial. Ahmedabad has made concerted efforts to identify the populations most at risk and adopt a multifaceted approach to communication to reach all community members, including those who cannot read. A color-coded alert system and partnerships with community leaders for verbal dissemination of information are key features of this inclusive strategy.

Enhanced and timely weather forecasting enables more effective heat planning and response strategies. During the formulation of the Ahmedabad HAP, the India Meteorological Department was able to provide forecasts of extreme heat conditions a little over 24 hours in advance. As the HAP was being developed, AMC and its partners determined that longer-term forecasts could be useful to prepare for heatwaves (Knowlton et al. 2014). This led to the establishment of a seven-day probabilistic temperature forecasting system, which was instrumental in enhancing the city's preparedness and response to impending heatwaves. The system was developed in partnership with the Georgia Institute of Technology and the Climate Forecast Applications Network. In cities without access to reliable local climate forecasts, support from national and international partners—including academic and research institutions and development agencies—could be pivotal in developing robust early warning systems.

3.2.7. Comprehensive financial preparedness in the Philippines

Aerial view of Manila, the capital of the Philippines. Credit: © Alexpunker/ istock.com

The Philippines is a highly disaster-prone country. At least 60 percent of its land area and close to 74 percent of its population are exposed to multiple natural hazards, including typhoons, earthquakes, floods, storm surges, tsunamis, volcanic eruptions, and landslides. Over the past 30 years, disasters have claimed the lives of 33,000 people and adversely affected 120 million people. It is estimated that earthquakes and typhoons cause an average of $3.5 billion annually in direct losses to public and private assets, amounting to over 1 percent of GDP. Climate change is expected to increase the frequency and severity of hydromet events, with recent estimates from climate modeling exercises showing that emergency response costs from typhoons could rise by over 50 percent for severe events. Disaster-related risk is heavily concentrated in the Metro Manila Region due to population concentration (World Bank 2020a).

To increase disaster resilience, the government undertook a comprehensive reform journey. Starting over a decade ago, with the enactment of the 2010 Philippines Disaster Risk Reduction and Management Act,[75] it took several more years for the country to conceptualize its financial resilience strategy. This was crucial, as from 2015 to 2018, the government spent an average of 4.3 percent of its total budget allocations each year on disaster response and rehabilitation (Qian et al. 2020).

Program

Following the destruction brought by Typhoon Haiyan, which severely impacted Tacloban City, the Philippine government adopted a disaster risk finance and insurance (DRFI) strategy in 2015. The strategy builds on a country-specific catastrophe risk model developed by the Department of Finance with World Bank support, paving the way for one of the most comprehensive financial preparedness

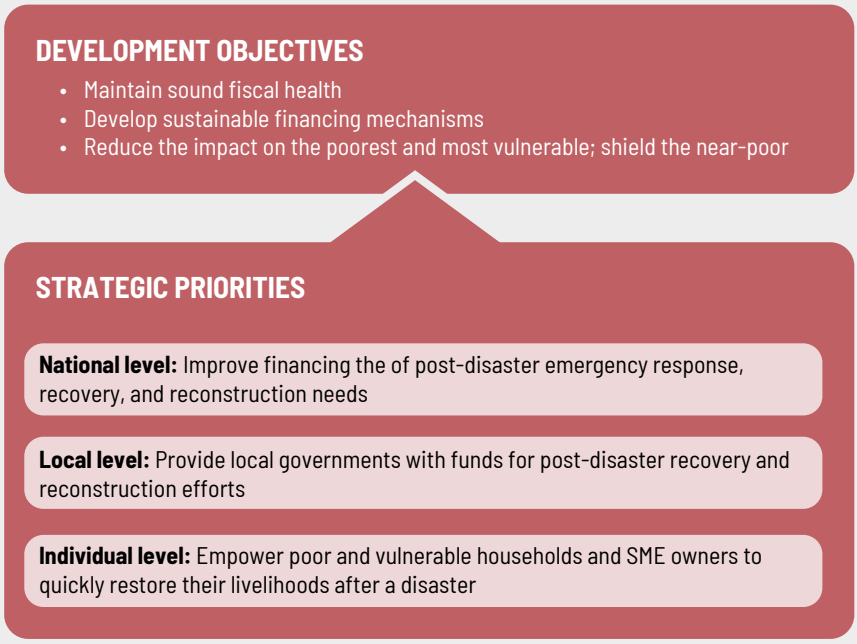
[75] https://www.officialgazette.gov.ph/2010/05/27/republic-act-no-10121/.

reform programs among emerging economies. It focuses on three elements: maintaining the national government's sound fiscal health even after a disaster, developing sustainable local government financing mechanisms, and reducing the impact of disasters on the poorest and most vulnerable (figure 28).

Since adopting the DRFI strategy, the country has introduced multiple initiatives to enhance disaster preparedness using a multilevel risk-layering approach (figure 29). For example, the government has put in place contingent financing, from the World Bank and other partners, to provide immediate liquidity to help the government manage the financial impacts of disasters,[76] and secured over $14 billion in risk transfer protection to improve fiscal resilience, including through a catastrophe bond, a parametric insurance program for local government units, and the 2024 National Indemnity Insurance Program (NIIP), which protects more than 130,000 schools. It has also instituted local disaster risk reduction and management funds, requiring local governments to set aside no less than 5 percent of their estimated revenues from regular sources, and established a parametric insurance program to transfer typhoon and earthquake risk away from the country to the international reinsurance market in local currency (World Bank Group 2021b). Finally, at individual level, it provides support to make agricultural insurance more affordable for Philippine farmers, especially the most vulnerable (Department of Agriculture 2022).

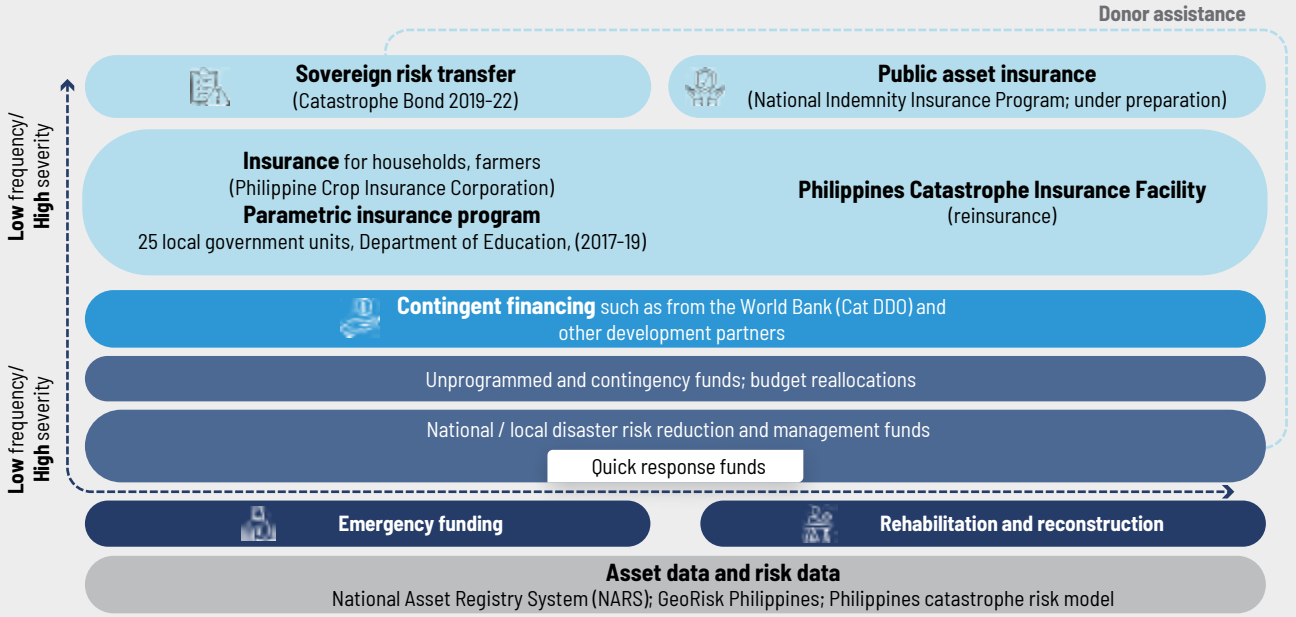
Having implemented the DRFI strategy, the government is now working to embed disaster risk considerations in its day-to-day operations—including asset management and the budget lifecycle—to ensure the sustainability of its risk management approach. Its ambitious "Build Better More" program is

FIGURE 28. PHILIPPINES DRFI STRATEGY



[76] https://www.worldbank.org/en/news/press-release/2023/11/17/wb-delivers-financial-boost-to-ph-to-strengthen-climate-preparedness-at-schools-health-facilities-commu?_gl=1*1kvh9y4*_gcl_au*MTYwODI10DA50C4xNzI0OTMyNzI0.

FIGURE 29. PHILIPPINES RISK-LAYERING STRATEGY



an example of the shift within government toward considering the entire asset lifecycle, from planning to decommissioning, rather than focusing solely on the initial investment. The country also adopted a national asset management policy in 2020,[77] and established the National Asset Registry System (NARS), which stores more than 350,000 asset records and has the analytical capabilities to inform its disaster risk finance (DRF) and asset management efforts (Bureau of the Treasury 2022).

Results

The DRFI strategy has mobilized the private sector through insurance, improving fiscal resilience and protecting more households and farmers, especially the most vulnerable. Over $500 million in premium subsidies from the national budget has also made agricultural insurance more affordable, resulting in an increase in insurance penetration to one-third of farmers (World Bank 2023b).

Payouts from several financial mechanisms have provided the government with funds to react to disaster-incurred damage. Triggered in 2022 by Typhoon Rai, the Catastrophe Bond paid out $52.5 million to the national budget and was used to finance the first NIIP for critical public assets.[78] The government also disbursed its contingency credits with the World Bank Cat DDO (World Bank 2024b), receiving $2 billion in budget support following disasters between 2011 and 2023. Finally, the parametric insurance program paid out around $28 million over two years.

While payouts have played a crucial role in financing response and recovery efforts, embedding DRFI into government systems to enhance financial resilience and incorporating it into the budget process has been even more significant. Following the adoption of the national asset management policy in 2020, several line agencies have now established

[77] https://law.upd.edu.ph/wp-content/uploads/2020/12/DOF-DBM-NEDA-Joint-Memorandum-Circular-No-2020-1.pdf.
[78] https://www.artemis.bm/news/philippines-cat-bond-triggers-on-typhoon-rai-odette-winds-52-5m-payout-due/#:~:text=The%20Philippines%20has%20a%20World,A%20tranche%20providing%20earthquake%20cover.

working groups that systematically look at asset lifecycles and are developing individual agency asset management plans. And since rolling out the NARS, which was essential for implementing the NIIP, the government has initiated the development of an annual disaster risk-based budgeting framework. This framework aims to make public financial systems more proactive in addressing disaster risks and ensuring that DRF instruments are integrated into annual budget planning and monitoring.

Key takeaways

Implementing a comprehensive risk-layering strategy takes time, and strong ownership is crucial for continuity. Consistently expanding its portfolio of DRFI solutions, the Philippine government met several challenges. For example, all stakeholders need to understand what role risk transfer instruments play and do not play. The parametric insurance payout process illustrates some of the challenges encountered, as cash payouts were successfully transferred to the national government but did not reach local governments due to a positive basis risk, a mismatch of policy objective and mechanism, government processes, and other issues (World Bank Group 2021b).

Working closely with legislative stakeholders is important, yet often overlooked. It is always difficult, but necessary, to justify budgeting for insurance premiums; and without understanding the principles or cost efficiencies of insurance, such proposals can face resistance. DRFI instruments can be extremely complex, in terms of both technical design and implementation, and it can take years to develop the policies and regulations necessary to establish a new DRFI tool or initiative. For example, before establishing the NIIP, the government spent several years collecting asset data, without which it would not have been feasible.

Engaging and harnessing the private sector will ensure DRFI instruments protect more people. It is impossible to address all disaster risk through public budget and development partner funding alone, and the Philippine government is exploring sustained ways to mobilize private sector finance. For example, it has invested a lot of resources in better protection for small and vulnerable farmers. Recognizing the limitations of tackling this solely through its own forces, the government is working to create a PPP between private insurers and the state insurer—the Philippine Crop Insurance Corporation—to leverage the latter's expertise and the private sector's operational efficiency and innovations to better protect Philippine farmers. It has also started to explore how to engage the private sector in its first NIIP for critical public assets.

Institutionalizing DRF will help ensure its sustainability and continuity. As a country with a mature DRFI program, the Philippines has already started working on embedding disaster risk financing into—and implementing the DRFI strategy through—the government's budget cycle. This will ensure that DRFI becomes part of the day-to-day government business. DRF also cuts across sectors and agencies: in the Philippines, no single agency is responsible for DRF. And, as finance, budgeting, and treasury functions are separate, working across budget oversight agencies is key to good coordination in, and longevity of, disaster risk finance and management. In-house capacity-building has proven fundamental to institutionalizing, growing, and developing the Philippines DRF program. The government and other key stakeholders have invested substantial efforts across engagement, instruments, and policies, ensuring government ownership and improving understanding of the benefits of DRFI instruments and policies.

3.2.8. Climate and disaster-resilient development in Vanuatu

▲ Turquoise coastline in Sanma, Vanuatu. Credit: © todaydesign/ istock.com

The development context in Vanuatu is highly influenced by its exposure to climate-related risk and geophysical hazards. As a SIDS, Vanuatu faces significant and interconnected climate and development challenges. These are exacerbated by its remoteness, high exposure to natural hazards, and limited economic diversification. Approximately two-thirds of the country's nearly 350,000 inhabitants live in rural areas with limited economic opportunities and rely heavily on subsistence activities—such as agriculture and fishing—for their livelihoods. Its six provinces and many islands, which are dispersed over a large geographical area, are administered through a decentralized governance structure, based on traditional village leadership.

Facing increased extreme weather events and damages, Vanuatu is in a near-constant state of response and recovery. Sea surface temperatures in the Southern Pacific are rising three times faster than the global average, leading to a significant increase in storms, droughts, storm surges, floods, landslides, and other extreme weather events.[79] The frequency and intensity of tropical cyclones have also surged due to climate change and the El Niño–Southern Oscillation. Between 2019 and 2023, 12 Category 1–5 cyclones made landfall in Vanuatu;[80] while the number of highly damaging Category 3–5 cyclones rose from one in 2003–13 to eight in 2013–23. In 2015, Tropical Cyclone Pam—one of the strongest to ever strike Vanuatu—caused estimated economic damages of $450 million (62 percent of national GDP in 2015) on 22 islands, with recovery efforts expected to extend until at least 2021 (Government of Vanuatu 2015). Located in the Pacific Ring of Fire, the country has experienced multiple earthquakes, landslides, volcanic eruptions, and tsunamis.

Program

Undertaking a comprehensive program of institutional strengthening and policy reform

[79] https://wmo.int/media/news/climate-change-increases-threats-south-west-pacific.
[80] Data compiled from Reliefweb (https://reliefweb.int/disasters?list=Vanuatu%20Disasters&advanced-search=%28C249%29) and Worlddata (https://www.worlddata.info/oceania/vanuatu/cyclones.php).

over the last decade, Vanuatu has adopted a multipronged approach to integrate climate and disaster risk and resilience into its policies, plans, legislations, and investments. Recognizing the escalating risks posed by climate change and disasters, the government has established a risk management framework and implemented institutional reforms, strengthened policies and legislation, and targeted investments in critical and vulnerable sectors and communities. Due to its limited number of government staff, Vanuatu has benefitted from technical support from development partners and regional organizations.[81] It has also leveraged the Framework for Resilient Development in the Pacific 2017–30, the first regional approach to integrate climate change considerations with disaster risk reductions, underscoring the importance of embedding climate and disaster resilience into development (SPC et al. 2016).

Institutional and policy changes have streamlined the policy and legislative framework and governance structure. In 2012, the National Advisory Committee on Climate Change and National Task Force for Disaster Risk Reduction and Disaster Management were merged into a single entity—the National Advisory Board on Climate Change and Disaster Risk Reduction (World Bank 2012)[82]—helping to improve coordination across sectors, government agencies, funders, and partners, and bringing civil society organizations into climate and disaster resilience efforts. To further enhance coordination and reduce fragmentation in finance and governance, the government also merged five departments in 2014 to establish the Ministry of Climate Change Adaptation, Meteorology, Geo-Hazards, Energy, Environment, and Disaster Management (MoCCA).[83]

These institutional changes prompted new legislative reforms and gave rise to the disaster and climate resilience objectives outlined in the 2030 National Sustainable Development Plan (2016–30). The government has made several reforms to meet the aspiration for a strong and resilient nation, such as repealing the Vanuatu Meteorology Services Act of 1989 and National Disaster Act of 2000, and replacing them with the Vanuatu Meteorology, Geological Hazards, and Climate Change Act of 2016 to establish mandates for both climate and geological hazards, and the DRM Act of 2019 to include climate-related risks.

Several other key reforms contribute to advancing the climate and disaster resilience agenda in Vanuatu. For example, the National Land Subdivision Policy 2019 establishes requirements for disaster and climate risk screening as part of the approval process of all new land subdivision development, while the National Disaster Recovery Framework 2021 promotes an integrated approach to postdisaster recovery activities. The Climate Change and Disaster Risk Reduction Policy 2022–30 sets out priority policy directives for both climate and disaster risk reduction, and the draft National Disaster Recovery and Resilience Bill 2024 provides a legislative framework for postdisaster recovery.

These policy and legislative changes are complemented by projects to support socioeconomic development and enhance the resilience of vulnerable communities, sectors, and islands. With funding from development

[81] This includes the Secretariat of the Pacific Regional Environment Programme (SPREP), the Pacific Islands Forum Secretariat (PIFS), the Pacific Community (SPC), and the University of the South Pacific (USP).
[82] https://www.nab.vu/.
[83] https://mocca.gov.vu.

finance institutions and donor programs,[84] the government has implemented several projects focusing on resilient infrastructure, climate-smart agriculture, and risk-informed land use and urban planning.

Results

Vanuatu's institutional strengthening and policy reform efforts have resulted in greater policy cohesion for climate adaptation and DRM. Consolidating multiple agencies into the MoCCA has brought together technical expertise across relevant fields, improving governance and policy implementation. Although still in the early stages of implementation, one review suggests that these policy changes are showing positive impacts (Hallwright and Handmer 2021). In 2019/20, Vanuatu allocated 15 percent of the national budget to improving resilience and natural resource management, one of the world's highest DRM budget allocations.

Integrating climate risk management, adaptation, and resilience into project design has also strengthened resilience across various dimensions. Projects implemented over the past decade include:

- **New standards for roads** to withstand climate and geophysical risks, supported by the Australian government, which included training island-based small businesses in construction methods that adhere to the new standards
- **Community projects**, such as providing clean and reliable water supply in remote and vulnerable areas; improving small road designs—drawing on the new standards—to provide all-weather access to markets and other critical services; introducing drought-resistant root crop varieties, such as sweet potatoes, and multicropping systems to manage highly variable rainy seasons; and building small footbridges to allow all-weather access to communities affected by increasing storm surge and sea level rise
- **Risk-informed urban planning** with multihazard risk mapping in Greater Port Vila and Luganville, expanded to include town planning for the provincial hubs of Lenakel in Tanna and Lakatoro in Malekula; upgrading selected informal settlements; and piloting a new greenfield subdivision in Port Vila[85]
- **Reconstruction efforts** following Tropical Cyclone Pam, including rebuilding or repairing roads, schools, and public buildings to meet climate and disaster resilience standards.[86] With a budget of approximately $12 million, road-related activities achieved a 29 percent economic rate of return, created local employment, and enhanced small business capacity. The project also built 40 schools, adhering to international best practices in structural safety standards, and upgraded 210 public buildings (mainly schools) to resilient standards, considering gender and inclusiveness. Field observations indicate that these efforts have mitigated damage from recent cyclones.

Implementing the new policies and operationalizing decentralized governance

[84] Over the past decade, the government has accessed around $140 million from multilateral development banks for climate resilience and DRM activities, including $120 million from the International Development Association and World Bank-administered trust funds for investment programs and development policy operations with the Cat DDO and about $18 million from the Asian Development Bank for the Greater Port Vila Urban Resilience Project (https://www.adb.org/projects/51335-001/main) and its Asia Pacific Disaster Response Fund after Tropical Cyclones Judy, Kevin, and Lola.

[85] https://projects.worldbank.org/en/projects-operations/project-detail/P173278.

[86] https://projects.worldbank.org/en/projects-operations/project-detail/P156505.

structure is delivering risk-informed settlements and planning.[87] Under the Land Subdivision Policy, six provincial and two municipal disaster and climate change committees have been established, which play a crucial role in disaster preparation, response, and recovery. In 2024, 49 new settlement subdivision applications are being screened for climate and disaster risks. The government has also continued its efforts to upgrade informal settlements that face multiple risks, enhance living conditions—including for poor and vulnerable groups, especially women and children—and promote resilient standards for new subdivision settlements.

Key takeaways

Achieving policy coherence and coordination remains challenging, but the shift from response to preparedness and resilient recovery shows promise. Despite clear progress in policies and outcomes, challenges persist, primarily due to limited government staff numbers, policy fragmentation, timeframes, and development partner and donor requirements, but also because the country is in near-constant disaster response and recovery mode. The Regional Pacific NDC Hub[88] could be a crucial platform for enhancing coherence in technical support but will require ongoing government leadership to strengthen its focus on climate-resilient development. Implementing a coordination mechanism for policy dialogue during budget support operations, like those used in other PICs, could also be beneficial and allow the government to build on its National Advisory Board on Climate Change and Disaster Risk Reduction. To implement such a mechanism, the government will need to strengthen its internal processes—including public financial management and reporting of climate and disaster resilience outcomes—and get commitment from key agencies.

Village and tree house, Tanna Island, Vanuatu. Credit: © Gerold Grotelueschen/istock.com

Progress toward climate and disaster-resilient development requires a programmatic approach with sustained and long-term commitment from all stakeholders. Developing and implementing policies and investment projects is a slow process, especially in countries confronted with multiple disasters, political instability, and changes to national and sectoral priorities. Vanuatu can expand risk-informed planning in development decisions from land subdivision to infrastructure, buildings, and communal land, supporting this through its decentralized governance structure, including mechanisms for flows of funds to subnational government entities. This would enable existing activities and assets in these sectors to respond to changes in risk and vulnerability, and cope with limited capacity—especially in poor, remote, and vulnerable communities—helping the government plan for longer-term investment and meet its aspiration of a "strong and resilient nation in the face of climate change and disaster risks", as outlined in its National Sustainable Development Plan.

[87] https://projects.worldbank.org/en/projects-operations/project-detail/P168749.
[88] https://pacificndc.org.

3.2.9 Supporting decentralization and strengthening local government for effective local climate action in Guinea

▲ Woman walking down the street in the town of Bolama, Guinea. Credit: © Siempreverde22/ istock.com

Climate change is a growing threat to Guinea's development and is predicted to disproportionately impact its rural areas, which are home to over 80 percent of the country's poor. Guinea is considered highly fragile, and 64 percent of its population lives in areas that are highly exposed to climate risks (USAID 2021). Coastal and highland flooding are recurring risks during the rainy season and inconsistent rainfall patterns are expected to worsen, threatening water quantity and quality. Together with rising temperatures, this will increase stress on agricultural livelihoods and food security for 70 percent of the population. Warming oceans, rising sea levels, pollution, and overfishing threaten Guinea's coastal communities and fishing industry. Pressure on the country's agriculture and water supply may increase its dependence on forest resources, threaten climate-vulnerable species, and prolong fire seasons in its mountainous and lowland forests. Rural populations will be disproportionally affected by the effects of climate change and may have to migrate to cities, putting pressure on resources and increasing tensions between groups (Clement et al. 2021). Climate change pressures increasingly provoke clashes between farmers, herders, and fishermen competing over shrinking resources (World Bank 2021). Women, youth, and other vulnerable groups—who constitute a higher portion of the rural poor—are at higher risk of being excluded from local development planning, and as a result, their climate adaptation and resilience needs are not prioritized.

Guinea has advanced decentralization with the creation of the National Fund for Local Development (FNDL), the National Agency for Local Government Financing (ANAFIC), and the Local Economic Development Fund (FODEL) in 2016. These bodies support resource distribution locally, especially from mining revenues. With Guinea ratifying its NDC to support local climate change adaptation, these bodies are essential.

Program

Guinea has developed an approach to identifying and responding to climate-related risks, natural disasters, conflicts and violence

at the local level, the *Approche Guinéenne pour Identification des Risques* (AGIR-the Guinean approach for identification of risks). AGIR reflects international best practice and proposes a methodology to improve the integration of climate change in local development planning and tools for participatory diagnosis with communities. A 2021 toolkit for localizing NDC commitments and investments (Government of Guinea 2021) provides guidance on partnerships and investment plans and defines the contributions of the ANAFIC and FNDL to climate action in mobilizing funding for climate resilience and clean energy solutions at local level.

The *Projet d'Appui a la Gouvernance Locale* or Guinea Support to Local Governance Project (PAGL) has supported the national and local governments with decentralization, local participatory planning, and aims, among other things, to improve national and local capacity for climate-resilient local development. In its first stage (2019–24), it supported the ANAFIC to operationalize the FNDL, incentivized the timely transfer of decentralized funding to local governments, and helped improve local government capacity to manage FNDL resources in a transparent and participatory manner and use participatory planning when spending the funds. In its second stage, the PAGL II (2023–28) aims to build on the achievements of this engagement.

Supporting climate adaptation is a central objective of the PAGL II. The project will invest $12.4 million in technical assistance and capacity-building support to help ANAFIC, local governments, and communities integrate and prioritize climate resilience in local development planning and monitor and report on the contribution of these investments. To help operationalize Guinea's NDC commitments, it will mobilize FNDL and FODEL to finance local-level mitigation and adaptation measures and coordinate with the Guinea Natural Resources, Mining and Environmental Management Project.

The PAGL II will also develop a monitoring, reporting and verification (MRV) tool to record the nature and size of climate-resilient and adaptive local investments funded by FNDL and FODEL and their responsiveness to risks identified through the diagnosis. The tool will be designed to feed into the national MRV system for climate change which the government is developing.

Results

Although only in its first year of implementation, the PAGL II has already achieved some results in terms of improving local government capacity to identify and respond to climate risks at local level. The project aims to increase the share of local investments that improve the resilience of the Guinean population. It does this by supporting the integration of a participatory climate risk diagnosis into the national harmonized guide for local development planning. This diagnosis will help ensure local government investments adequately prioritize adaptive measures in their annual investment plans.

The project also introduces a performance-based condition (PBC) to incentivize the integration of this participatory climate risk diagnosis into the local development planning process. Known as PBC4, it is intended to verify and reward the implementation of the nine tools that constitute the participator diagnosis and the integration of corresponding adaptation and mitigation measures into annual investment plans. The end goal is for 90 percent of local governments to have executed an annual investment plan that reflects the climate resilience priorities identified during the socioeconomic diagnosis. PBC4 will condition

$8 million financing on the achievement of incremental yearly targets corresponding to the development and use of the climate risk tools to inform investment priorities (table 4). The project has already achieved its target for Year 1, with the integration of the nine tools into the national harmonized guide for local development planning. Training on these tools will be rolled out in 2024.

The PAGL II also aims to ensure that at least 50 percent of local government annual investment resources are tagged as contributing to climate mitigation or adaptation by project end. This indicator seeks to measure the project's contribution to a greater integration and prioritization of climate mitigation and adaptation measures in the local development fund investments. Improvements against the baseline value are expected from 2025 due to the sequencing of corresponding technical assistance and capacity building activities, and the ANAFIC is currently leading efforts to define climate-resilient/adaptive local investments to enable this kind of tracking. Two additional intermediary indicators track capacity-building efforts and the use of an MRV tool to track and record climate-resilient investments.

Key takeaways

Effective local climate action requires stable, empowered local governments with national support. Lessons from the PAGL II in Guinea emphasize the need to strengthen local government structures, build capacity at all levels, support the National Agency for Local Government Financing's accreditation with to access vertical green climate funds, and integrate mining sector actions for additional funding. Key actions include recruiting local development agents, ensuring timely fund replenishment, building climate adaptation capacity, improving local climate data collection, and establishing a robust monitoring framework. Supporting the agency's accreditation and integrating mining sector funds into local plans are essential for enhancing climate resilience.

TABLE 4. PBC4 TARGETS AND FINANCING

PBC	BASELINE	ANNUAL TARGETS			
		YEAR 1	YEAR 2	YEAR 3	YEAR 4
PBC 4. Participatory diagnosis of climate risks	0	80% of local governments are trained on the climate resilience tools of the harmonized guide for local development planning	50% of local governments have executed an annual investment plan that reflects the climate resilience priorities identified during the socioeconomic diagnosis	70% of local governments have executed an annual investment plan that reflects the climate resilience priorities identified during the socioeconomic diagnosis	90% of local governments have executed an annual investment plan that reflects the climate resilience priorities identified during the socioeconomic diagnosis
$7,980,590		**$2,582,210**	**$2,428,020**	**$2,207,750**	**$762,610**

Conclusion

An opportunity to replicate successes and scale up action

This report is a mix of good and less good news. On the one hand, it is clear that development and resilience reinforce each other, making it possible to find strong synergies between the development agenda and the need to adapt to a changing climate. On the other hand, climate change makes development more expensive, as it requires "better" development and investments to address specific needs to adapt to climate change, such as upgrading coastal defenses in the face of sea level rise. Climate change also increases the severity of the consequences of delaying development, as climate impacts could add to the many barriers that low- and middle-income countries face on their journey toward prosperity and high income.

The state of adaptation and resilience is also a mixed picture. The World Bank's A&R readiness assessments in 44 countries illustrate the gaps and limits in adaptation action. Yet this report also identifies many examples of innovative and effective interventions in both the private and public sectors that build the resilience of people, firms, communities, or countries. But, while there are good examples of interventions for specific sectors or hazards, no country has tackled all the risks to the full extent possible. With limited capacity and financial resources—especially in a context of high public debt across emerging economies—closing the gaps will be a challenge.

Identifying clear priorities and replicating what works offers a way forward. Countries are making good progress in identifying key risks and priorities to build resilience in their NAPs or NDCs, and other products, such as the World Bank Group's CCDRs, contribute to the prioritization process. Once countries have clearly identified and selected their priorities, they can find good practices—including among those summarized in this report—to replicate. Today, there are enough good practices that can be replicated to accelerate progress toward more resilience and higher adaptation capacity. And the World Bank will continue to monitor actions in various countries, measuring results along different metrics and dimensions and expanding this collection of successful stories and strategies. Its objective is to produce new knowledge and stronger evidence on the policies, technologies, or approaches that deliver the best results, contributing to a virtuous circle toward higher resilience and better, safer lives.

Appendix

Adaptation and resilience (A&R) readiness assessment methodology

The World Bank A&R readiness assessment provides a whole-of-government, whole-of-economy approach to evaluate a country's A&R policy, institutional and capacity preparedness and implementation. Using the Adaptation Principles framework (Hallegatte, Rentschler and Rozenberg 2020), the A&R readiness assessment evaluates a country's progress and gaps in A&R actions and capacity development. This assessment can help decision-makers, such as climate change coordinating bodies and central ministries, establish or strengthen the enabling conditions and policy interventions and implementation for improved A&R preparedness. The approach complements detailed sectoral assessments and can be adapted to reflect a country's A&R priorities, such as those identified in their national adaptation plans, nationally determined contributions, or long-term strategies.

An Excel-based scoring tool supports the A&R assessment using a mix of quantitative and qualitative indicators (around 180 indicators for a full assessment), selected to support evaluation across all the domains and action areas. The tool adopts a traffic light system to rate the country's progress in each A&R indicator and preparedness area. The scoring system is based on three categories:

NASCENT (1)	The country does not meet the standard or includes areas that are at an early stage of development, or ranks in the bottom tercile of a benchmark group.
EMERGING (2)	The country partly meets the standard, has progressed beyond the early stage, or is ranked in the middle tercile of a benchmark group.
ESTABLISHED (3)	The country meets the standard or is ranked in the top tercile of a benchmark group.

Each indicator is rated and assigned a score of 1 (nascent), 2 (emerging), or 3 (established), according to available data and information, and using a wide range of sources and methods, including benchmarking against peer countries and expert judgment. Indicators are then aggregated to provide a scorecard with average scores for each priority action and pillar, and the country as a whole (table A.1). One key feature of the approach is that qualitative indicators (typically two-thirds of all indicators) are converted to quantitative scores that can be then aggregated to evaluate a country's overall performance. This system offers a simple way to identify gaps, develop recommendations on areas for improvement, prioritize actions, facilitate

target setting, and monitor progress across key aspects of adaptation and resilience.

While the countries were assessed using a consistent framework and the same traffic light scoring approach, there are important caveats to consider when assessing results summarized in table A.1. First, the assessments were completed at different times over a three-year period. Second, the indicator coverage varies across countries: some were full assessments with more than 180 indicators, while others—for example, the Caribbean countries—used a reduced set of 30–60 indicators, based on data availability and scope of analysis. Third, the comparator benchmark group used for each country's quantitative indicators were recalculated for this analysis, using the rest of world as the comparator group.

TABLE A.1. SUMMARY OF COUNTRY A&R READINESS SCORES

COUNTRY/ECONOMY	FOUNDATIONS: Economic growth and inclusive development	PRIORITY 1: Adaptation of people and firms	PRIORITY 2: Land use plans and critical public assets	PRIORITY 3: Disaster risk management	PRIORITY 4: Macrofiscal	APPLICATIONS: Institutions, implementation, and monitoring	OVERALL A&R READINESS SCORE
Albania							
Antigua and Barbuda							
Armenia							
Austria							
Azerbaijan							
Bahamas, The							
Barbados							
Belize							
Bhutan							
Bosnia and Herzegovina							
Cabo Verde							
Cambodia							
China							
Colombia							
Côte d'Ivoire							
Dominica							
Dominican Republic							
Ecuador							
Grenada							
Guinea							

COUNTRY/ECONOMY	FOUNDATIONS: Economic growth and inclusive development	PRIORITY 1: Adaptation of people and firms	PRIORITY 2: Land use plans and critical public assets	PRIORITY 3: Disaster risk management	PRIORITY 4: Macrofiscal	APPLICATIONS: Institutions, implementation, and monitoring	OVERALL A&R READINESS SCORE
Guyana							
Haiti							
India							
Jamaica							
Kosovo							
Moldova							
Montenegro							
North Macedonia							
Peru							
Poland							
Senegal							
Serbia							
Sint Maarten (Dutch part)							
St. Kitts and Nevis							
St. Lucia							
St. Vincent and the Grenadines							
Suriname							
Tajikistan							
Togo							
Trinidad and Tobago							
Türkiye							
Turks and Caicos Islands							
Uganda							
Uzbekistan							

Legend:

Nascent <- -> Established

Note: The table illustrates the average score for each pillar and the overall A&R readiness score using a gradient of colors as shown in the legend and following the traffic light scoring approach, which ranges from red for a score of 1 (nascent) to green for a score of 3 (established). Grey indicates data not available in the country assessment.

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