



RESEARCH REPORT

# Articulating a Program for Resilience

## The Landscape of Evidence, Actions, and Geographies

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The nonprofit Urban Institute is a leading research organization dedicated to developing evidence-based insights that improve people's lives and strengthen communities. For 50 years, Urban has been the trusted source for rigorous analysis of complex social and economic issues; strategic advice to policymakers, philanthropists, and practitioners; and new, promising ideas that expand opportunities for all. Our work inspires effective decisions that advance fairness and enhance the well-being of people and places.

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# Executive Summary

Resilience is here to stay. What emerged as a theoretical societal ideal has now been operationalized by numerous city governments, infrastructure engineers, and grassroots organizers as a set of actions necessary for their short-term planning and long-term survival. Just in the last year alone, the calls for resilience interventions from all sectors—public, private, and civil—have expanded to the point where specific actions are not only suggested, but urgent. The current global pandemic only brightens the spotlight on the gaps in collective and individual action to prevent, respond to, and recover from catastrophic shocks. However, the pandemic also presents a new component to a fundamental challenge to the resilience movement: all shocks are not created equal.

Nor are all interventions designed to address them. Into the evolving world of resilience policies, programs, and actions, the Adrienne Arsht-Rockefeller Foundation Resilience Center (the center) was launched in April 2019 with a stated goal of helping 1 billion people worldwide become more resilient in 10 years. At the time of its founding, the center partnered with the Urban Institute to review fundamental science and policy documents to assess areas for global action. Review criteria for selecting opportunities included the strength of their evidence base; their propensity for immediate implementation, particularly in the communities and places with the most urgent needs; their universality, scalability, and replicability across global contexts; and their potential for producing leveraged return to seed investments. That preliminary investigation resulted in six categories or “action areas”: community infrastructure, public finance, direct financial services, insurance, education and awareness, and food security.

Since then, the resilience movement has continued to evolve as the urgency and magnitude of the need to build have increased. Consequently, the center has partnered with the Urban research team again to further investigate the depth of the evidence base—including untested emerging tools and services among the leading entities and thought leaders in each action area—to provide more definition to the opportunities, and to identify the mix of potential geographies, their contexts, and the populations in question to assess the maximum potential reach for each opportunity’s implementation. The landscape of contemporary stakeholders is also considered.

The opportunities, filtered through the range of potential interests and capacities, form the possible points of entry for any program in this field. However, a few opportunities continue to meet the original criteria for mass replicability and reasonable resource investment. These areas are summarized in table ES.1.

TABLE ES.1

## Summary of Action Areas Findings

Action areas and opportunity categories	Challenge	Evidence	Opportunities
<b>Community Infrastructure</b>			
<i>Resilience standards</i>	There are little to no requirements for meeting future conditions, and they have not been integrated into decisionmaking.	Standards work, but only when supported by enforcement capacity and applied to existing infrastructure as well as new.	International standards organizations, voluntary industry guidelines, and multi-lateral/national advocacy could help.
<i>Cost-benefit analysis</i>	The evidence for proving benefits of resilient infrastructure (including that using screens) outweigh costs must grow.	Specific resilience CBA innovations have been employed in a handful of developing contexts and mainly for large projects.	Expanding on these innovations, standardizing them, and assessing their efficacy would fill that evidence void.
<i>Regional collaboration</i>	Infrastructure is most efficient when it addresses conditions that extend beyond traditional borders and budgets.	Collaborations between counties, cities, and districts like the Southeast Florida Climate Compact improve decisions.	Subnational governments in large nations could design more efficient resilience. Resourcing these entities could spur that.
<b>Public Finance</b>			
<i>Public funds</i>	Public funds are increasingly stretched to meet basic needs, with few dedicated to considering resilience needs.	Multilateral resilience, adaptation, and sustainability funds have been effective, but insufficient, in providing resources.	Advocating increases in the dedicated funds globally would immediately expand credit facilities and guarantees.
<i>Bond finance</i>	Bond finance is still predicated on the financial capacity of issuing public agencies and not on the risks to likely shocks.	Very early bond issuances for resilience infrastructure appear to be good investments as well as provide co-benefits.	Opportunities to expand private investment in bonds involve credit facilities and guarantees and direct purchase.
<i>Specialized finance and public-private partnerships</i>	Arrangements for resilience finance schemes have been resource intensive and focused on specific projects.	There have been cases of effective financial and technical performance in projects funded through unique schemes.	Developing best practices, standards, and case studies of project-specific finance with private investors may seed more.
<i>Debt capacity assistance</i>	Many jurisdictions most in need of resilience investment have the least capacity to take on debt or design projects.	Debt preparation assistance programs and project preparation assistance facilities have shown early signs of expanding funds.	Collaborations and resources for capacity providers (e.g., Adaptation Fund and environmental groups' projects) expands.
<b>Direct Financial Services</b>			
<i>Cash transfers</i>	Traditional safety net programs have not been targeted to conditions or circumstances related to specific shocks.	Safety net programs are underfunded, occasionally inefficient, and cumbersome for eligible individuals but quite effective.	Providing individual aid before shocks, rather than through relief or recovery aid agencies, could be more efficient.
<i>Savings</i>	Household savings are rare and are often targeted to long-term needs unrelated to likely global shocks.	Savings are a proven and effective way for families to absorb shocks of all kinds, but most families cannot afford to save.	Matched or leveraged rainy day funds with local financial institutions promote financial inclusion and individual buffers.

Action areas and opportunity categories	Challenge	Evidence	Opportunities
<i>Microfinance</i>	Other revolving finance tools for poor households have not been applied to meet specific shocks.	Microfinance loans focused on a specific loan use have been successful, provided clear instructions and guidelines.	Working with existing civil and private financial lenders in this space could promote resilience microcredit pilots.
<i>Remittances</i>	Remittances flow toward high-vulnerability regions, yet that money is not channeled to a collective benefit.	Remittance programs with a shared community purpose have occasionally overcome traditional pooling problems.	Working with cash transfer organizations and grassroots organizers at both ends of remittance flows could amass new funds.
<i>Financial literacy</i>	Financial planning and preparation courses do not integrate the range of shocks to which products could apply.	Financial planning and literacy, combined with direct aid, often can be used for shocks like medical emergencies.	Curricular tools and sponsored literacy campaigns could include a range of shocks in preparation guidance.
<b>Insurance</b>			
<i>Sovereign/municipal insurance</i>	Governments, particularly those that are most vulnerable, are often forced to self-insure against likely shocks.	Pooling insurance risks across jurisdictions could help spread and manage the risks over time.	Working with reinsurers and multilateral backstops could expand current models such as in the Caribbean.
<i>Property insurance</i>	Hazard insurance varies widely across nations and even subnational governments, and the costs are increasing.	Insurance is a proven shock mitigation technique but must reflect risk, be affordable, and encourage good behaviors.	Research and pilots of risk pools of owners with parametrically defined policies and claims could expand reach and burden.
<i>Microinsurance</i>	Many households have assets whose value is too small for retail insurers but whose loss would be devastating.	Like microfinance, the practices of micro-insurance apply for specific households and institutions, and the scale is mixed.	Working with insurers and micro-financiers could test appropriate policies (e.g. means-tested insurance subsidies).
<i>Health insurance</i>	Health insurance is not universal, and its costs often exceed the capacity of the most at-risk populations.	Health insurance and consequent expansion of health care providers improve health outcomes for many conditions.	Expanding insurance policies with providers to encourage coverage of climate change's health effects may help.
<b>Education and Awareness</b>			
<i>General risk awareness</i>	Educational campaigns and press coverage of long-term risks involving complex information have a modest effect.	Tailoring of messages and the quantity of messaging suggest that more profound risks get pickup, though action is unclear.	Communications scholars and campaigns could develop global messaging demonstrations and assessments.
<i>Targeted outreach (alerts)</i>	Alert systems have improved but are still not available in all contexts and in relation to all likely shocks.	Alert systems, when planned with appropriate messages and media, can reduce the loss of lives and assets.	Global emergency programs need resources, technology, and advocacy assistance to reach the underserved.
<i>Local knowledge</i>	Local understandings of environmental change are not integrated into scientific assessments or public planning.	Conducted authentically, grassroots engagement and resources yield effective solutions, though it can be time-intensive.	Funders could engage grassroots to complement science on localized risks and build community resilience capacity.
<i>Arts and culture</i>	Literary, performance, and visual arts have not heightened awareness of global behavioral change and actions.	Global media, combined with local cultural production, have been used to heighten awareness of local shocks.	Promoting funding for and networks of artistic collaboration could provide the seed for investment in resilience arts.

Action areas and opportunity categories	Challenge	Evidence	Opportunities
<b>Food Security</b>			
<i>Research and development</i>	Agricultural research and development is needed for alternative food production and supply in rapidly changing conditions.	Research has been successful in producing high yields and reducing the dependence on farming in developed nations.	Opportunities are limited to further support research with limited resources given its costliness and long-term output.
<i>Agricultural livelihoods</i>	Like the wider safety net, targeted programs for rural farming communities do not reach all the neediest households.	Safety net programs are proven in developing contexts, depending on design, benefit size, and delivery mechanisms.	Providing individual aid after shocks such as crop failures could be a test for other, broader safety net programs.
<i>Crop insurance and finance</i>	Rural agricultural communities are often at the mercy of environmental changes and have limited financial tools as buffers.	Cases of expanded insurance and finance, particularly for women, have expanded sustainable farming and stabilized families.	Providing aid before crop failures could be more cost-effective for aid agencies as well as broader safety nets.
<i>Resource stewardship</i>	Securing the sustainability and quality of resources such as water and energy is a challenge globally.	Food production is dependent on basic resources that when jeopardized will result in massive losses.	Environmental advocacy and stewardship pilots could improve local resources that indirectly boost long-term resilience.
<i>Nutrition</i>	Improved economies increased reliance on unsustainable food demand, increasing vulnerability in agricultural communities.	Livestock's effects on natural resources and livelihoods are noted. Campaigns to change nutrition have middling effects.	Promoting sustainable food demand may be targeted, but the resilience benefits on food supplies would be diffuse.



The range of potential opportunities follows patterns that purposefully mirror the original criteria. Even though the scholarship and practice are largely nascent in these areas—particularly in relation to resilience terms and shock—there is often already a preliminary evidence base and knowledgeable partners that can be points of entry. In virtually every category of potential action, the immediate recommendations for opportunities involve seeding investments in fundamental research, convening, pilots, and demonstrations in strategically selected places that could serve as the proof of concept for scaling.

Pilots should ideally be conducted for replicable tools and services, rather than place-based investments, given the kinds of universal platforms, knowledge bases, and program scales needed. Some pilots and demonstrations will need a launching pad. However, these sites should always be selected with the broader scale in mind. Given the range of units of the interventions presented, working with global partners such as multilaterals could reduce the transactional costs for investors and more effectively yield resilience at scale.

Now is the time to match resources to aspirations. As the resilience movement continues to evolve during the current global crises, the selection and mix of opportunities presented here could prove effective for multiple shocks and in places across the planet. The shocks are certainly not ending, nor is the need to become more resilient to them.



# Introduction

This report assesses the range of opportunities within select categories for building resilience. The work builds off a preliminary survey of actions defined by seminal, peer-reviewed consensus documents from the fields within the global conversation on resilience—including climate adaptation, disaster mitigation, vulnerability to and displacement from shocks, and risk management. By focusing on a subset of actions that are potentially replicable in all contexts—or at least a substantial subset of contexts with the most need of intervention, the work provides a menu of entry points for public-, private-, and civil-sector organizations with an interest in supporting these fields and, ultimately, the communities faced with the most critical challenges to their resilience.

## The Resilience Challenge

The challenge—expanding “the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning” (IPCC 2014)—continues to grow. Expanding urbanization and increasing exposure to environmental and security hazards affects all places on the planet, but particularly the most socially, economically, and politically vulnerable communities (IPCC 2012). The need is real, and massive.

Yet a practical task for meeting this need persists: defining the specific disturbances. Evaluations of previous resilience programs have noted that operationalizing the concept of resilience in policies, programs, and services often requires specifying the shocks against which communities are meant to be resilient (Martín and McTarnaghan 2018). In fact, much of contemporary resilience scholarship and practice comes via the occasionally overlapping worlds of climate adaptation and emergency management. In different contexts, resilience could alternately mean responding to climate change’s effects, to large-scale hazard events of any kind, or to other economic and social catastrophes. It also inherently implicates the chronic stressors—racism, gender discrimination, and income inequality, to name a few—that exacerbate vulnerability to shocks.

In light of the current COVID-19 pandemic, for example, the concept of resilience and implementation of resilient interventions are likely to change further in scope (to integrate health shocks), in meaning (the interrelatedness and cascading nature of multiple shocks in lived experience), and in practice (simultaneity of individual actions, collective norms, and institutional transformation). In short, the options are overwhelming. Articulating any one or a series of interventions to address a shock (or shocks) for a given community (or communities) and its stressors is daunting.

Fortunately, there are precedents. Programming, policymaking, and service offerings over the last decade have explicitly attempted to expand the resilience capacity globally. Some of these interventions have focused exclusively on implementation in areas discussed in this report, typically attuned to a defined set of shocks, such as global climate change: improved physical infrastructure; funding for that infrastructure; social safety nets; insurance; educational campaigns and grassroots participation; and food supply chains. Others have focused on specific sectors or systems, such as water, wildlife, or energy supplies. And still others have looked at transformations to underlying governance systems and institutions that could support any of these implementation areas or sectors; the Rockefeller Foundation-pioneered 100 Resilient Cities program is an example of this institutionalization approach. There are unanswered questions about the efforts' structure and efficacy, but also many lessons.

Into this evolving landscape of resilience, the Adrienne Arsht-Rockefeller Foundation Resilience Center (the center) was launched in April 2019 with a stated goal of reaching 1 billion people worldwide in 10 years, or by 2030. Center leadership and funders have considered “a range of evidence-based and innovative approaches, including policy frameworks, finance and risk transfer tools, and technology and communication strategies, including the performing arts” to reach their goal.

That same month, the center partnered with Urban Institute's resilience researchers to survey contemporary literature and practice to provide a solid foundation in scholarly evidence and practical insights for wider consumption. Urban surveyed all seminal, peer-reviewed, and global consensus-based documents such as those produced by the International Panel on Climate Change (IPCC), the Global Assessment Report on Disaster Risk Reduction from the United Nations Office for Disaster Risk Reduction (UNISDR), the International Monetary Fund (IMF) and other World Bank Group agencies, and reports from the United Nations High Commissioner for Refugees as well as credible global research organizations like the Munich Climate Insurance Initiative and the International Displacement Monitoring Center. Urban produced a preliminary tabulation of potential resilience activities (table 1). These were culled based on four criteria:

1. Supported by sufficient and, when available, rigorous evidence from scholarship and practice
2. Capacity to quickly serve individuals, households, and communities, particularly communities that are the most socially, financially, and physically vulnerable to shocks—that is, to be quickly implemented or “shovel-ready” within one decade
3. Scalability across geographies, rather than place-dependent strategies, to ensure replicability
4. Likelihood of partnership with credible entities to leverage the center's resources.

TABLE 1

## Preliminary Areas for Resilience Action, with Categories and Examples per Area

Category		Examples of Options
<b>Structural/ physical</b>	<i>Engineered and built environment</i>	Sea walls and coastal protection structures; flood levees and culverts; water storage and pump storage; sewage works; improved drainage; beach nourishment; flood and cyclone shelters; building codes; storm and waste water management; transport and road infrastructure adaptation; floating houses; power plants and electricity grids
	<i>Technological</i>	New crop and animal varieties; genetic techniques; traditional technologies and methods; efficient irrigation; water-saving technologies, including rainwater harvesting; conservation agriculture; food storage and preservation facilities; hazard mapping and monitoring technology; early warning systems; building insulation; mechanical and passive cooling; renewable energy; second-generation biofuels
	<i>Ecosystem-based</i>	Ecological restoration, including wetland and floodplain conservation and restoration; increasing biological diversity; afforestation and reforestation; conservation and replanting mangrove forest; bushfire reduction and prescribed fire; green infrastructure (e.g., shade trees, green roofs); controlling overfishing; fisheries co-management; assisted migration or managed translocation; ecological corridors; ex situ conservation and seed banks; community-based natural resource management; adaptive land use management
	<i>Services</i>	Social safety nets and social protection; food banks and distribution of food surplus; municipal services, including water and sanitation; vaccination programs; essential public health services, including reproductive health services and enhanced emergency medical services; international trade
<b>Social</b>	<i>Educational</i>	Awareness raising and integrating into education; gender equity in education; extension services; sharing local and traditional knowledge, including integrating into adaptation planning; participatory action research and social learning; community surveys; knowledge-sharing and learning platforms; international conferences and research networks; communication through media
	<i>Informational</i>	Hazard and vulnerability mapping; early warning and response systems, including health early warning systems; systematic monitoring and remote sensing; climate services, including improved forecasts; downscaling climate scenarios; longitudinal data sets; integrating indigenous climate observations; community-based adaptation plans, including community-driven slum upgrading
	<i>Behavioral</i>	Accommodation; household preparation and evacuation planning; retreat and migration, which has its own implications for human health and human security; soil and water conservation; livelihood diversification; changing livestock and aquaculture practices; crop-switching; changing cropping practices, patterns, and planting dates; silvicultural options; reliance on social networks
<b>Institutional</b>	<i>Economic</i>	Financial incentives, including taxes and subsidies; insurance, including index-based weather insurance schemes; catastrophe bonds; revolving funds; payments for ecosystem services; water tariffs; savings groups; microfinance; disaster contingency funds; cash transfers
	<i>Laws and regulations</i>	Land zoning laws; building standards; easements; water regulations and agreements; laws to support disaster risk reductions; laws to encourage insurance purchasing; defining property rights and land tenure security; protected areas; marine protected areas; fishing quotas; patent pools and technology transfer

Category	Examples of Options
<i>Government policies and programs</i>	National and regional adaptation plans, including mainstreaming climate change; subnational and local adaptation plans; urban upgrading programs; municipal water management programs; disaster planning and preparedness; city-level plans, district-level plans, sector plans, which may include integrated water resource management, landscape and watershed management, integrated coastal zone management, adaptive management, ecosystem-based management, sustainable forest management, fisheries management, and community-based adaptation

**Source:** Adapted from table 14-1 in Intergovernmental Panel on Climate Change, *Climate Change 2014: Impacts, Adaptations, and Vulnerability, Part A* (New York: Cambridge University Press, 2014).

## The Action Areas

Urban scholars reviewed additional peer-reviewed and gray literature to refine the proposed a list of actions further. The researchers confirmed reputable evidence for solutions classified into six accessible groupings:

- **Community infrastructure**, including design, construction, and maintenance standards and tools that integrate the latest climate projections and ensure appropriate upkeep while legitimizing public or private investment
- **Public and alternative financing and finance capacity for infrastructure** building off traditional finance facilities such as bonds complemented with green finance and debt capacity building
- **Direct financial assistance services** such as “rainy day” savings and financial counseling, particularly for unbanked or underserved groups including women and the poor
- **Hazard insurance products** ranging from guarantees for catastrophe bonds to innovations in retail property insurance that support households at all income levels
- **Educational and awareness campaigns** that inform mass populations of risks while harnessing messaging techniques to alter behaviors and encourage prevention and preparedness among family and community decisionmakers and integrate grassroots solution ideation
- **Food security** interventions that ensure a continued supply chain for both urban and rural populations despite changing temperatures, soils, and water supplies

These six categories of interventions rank among the most repeatedly cited in the literature and by global practitioners and multilateral organizations as being critically necessary for building resilience to climate change’s effects and mitigating their related environmental shocks and societal disruptions. The areas are relatively agnostic to the specific shocks in question, though much of the underlying literature

from which the areas emerge focus on climate shocks. Most the areas also simultaneously address chronic stressors, particularly in relation to poverty; those opportunities for “co-benefits” between reducing exposure and vulnerability are highlighted throughout this report. Ultimately, these strategies—or action areas—are among the best chances for innovation and pilot testing that requires modest resources to achieve multiple resilience ends.

Throughout that early analysis and the current report, the researchers have continued to structure the content of the work across the six original action areas, with each action area containing three to five *categories* or strategy groups, which, in turn, contain several *opportunities* for action or intervention that address a core challenge for resilience-building.

## Overview of Current Report

Following the preliminary review of the landscape of resilience interventions options, the center sought out a deeper dive into the evidence base for specific activities within the categories of each action area, along with a projection of the geographic reach from potential scaling, and the current range of active stakeholders.

### Methods

To conduct the work, Urban researchers first implemented an exhaustive literature review and survey of contemporary practice. This included mining of Urban’s Information Resources functions through which researchers have desktop access to a virtual collection of more than 9,000 scholarly journals plus other information resources across the internet through explicit tag searches, as well as “snowballing” of citations identified in the original seminal texts used in the preliminary survey. All possible monographs were then screened for relevance before being added to a broad bibliography.

From the final list, the researchers produced an annotated bibliography that provides sufficient detail about the source—including level of rigor and authors’ institutional affiliations—to link to other sources and provide a picture of the overall state of literature. Rigor for each source was classified on a scale from “weak” for exploratory works or descriptive sources, to “middling” for descriptive sources with some analysis or basic outcome studies, to “strong” for methodologically sound experimental or quasi-experimental research findings. For each category of literature (matched to the categories of resilience opportunities in each proposed action area), a summary of the state of literature was produced. For all the categories, the state of literature is preliminary—reflecting the overall nascent

condition of resilience interventions. Researchers consequently converted the annotated bibliographies into the narrative literature reviews provided in this report.

The reviews also provided critical background information to support the development of structured interview protocols with leading practitioners and scholars in each action area. The purpose of the interviews was to collect information from key thought leaders regarding the status and future potential of their current tools, services, and other activities in relation to one or more action areas identified in Urban's review. Because published literature typically lags current activities, these insights were intended to gather the most recent information for this review. A structured protocol was developed to confirm Urban's categorization of opportunities and their definitions, affirm or revise Urban's depiction of the state of the practice, document the individual's or organization's current related work, discuss alternative solutions, and elicit recommendations for action and intervention. All respondents were provided privacy disclaimers. Urban has removed potential identifiers in this study.

Finally, Urban conducted an extensive data collection effort to map indicators relevant to each action area. Data sources are only from credible multilateral sources, such as the World Bank or United Nations. For each category within the proposed action areas, Urban tabulated its likely unit of intervention (e.g., individuals, communities, or city or national governments) and the scale at which applications of the action could foreseeably affect those units (e.g., all individuals in low-income nations or national governments in high-exposure geographies). The purpose of this mapping exercise is to suggest possible geographic needs and challenges, and the potential reach of subsequent actions.

## **Preliminary Geographic Consideration**

To begin the process of mapping opportunities onto specific places in need of resilience-building tools and services, the researchers conducted a series of data collection efforts focused on fundamental indicators of challenges that are relevant to all action areas. For example, the overall population of nations (figure 1) provides a general scale for interventions along with serving as a fundamental tool to derive a few per capita or proportional indicators in later chapters. Inequality within that population (figure 2) highlights the persistence and magnitude of poverty. A fundamental understanding of population and poverty ranges also provides insights for designing an opportunity strategy that maximizes the populations that could be served by a given opportunity.

More substantive are the charts displaying the most recent tallies of shocks that induce displacement and potential migration, especially disaster events (figure 3), along with the total numbers of displaced populations for both (figures 4 and 5). These not only show where current shocks have

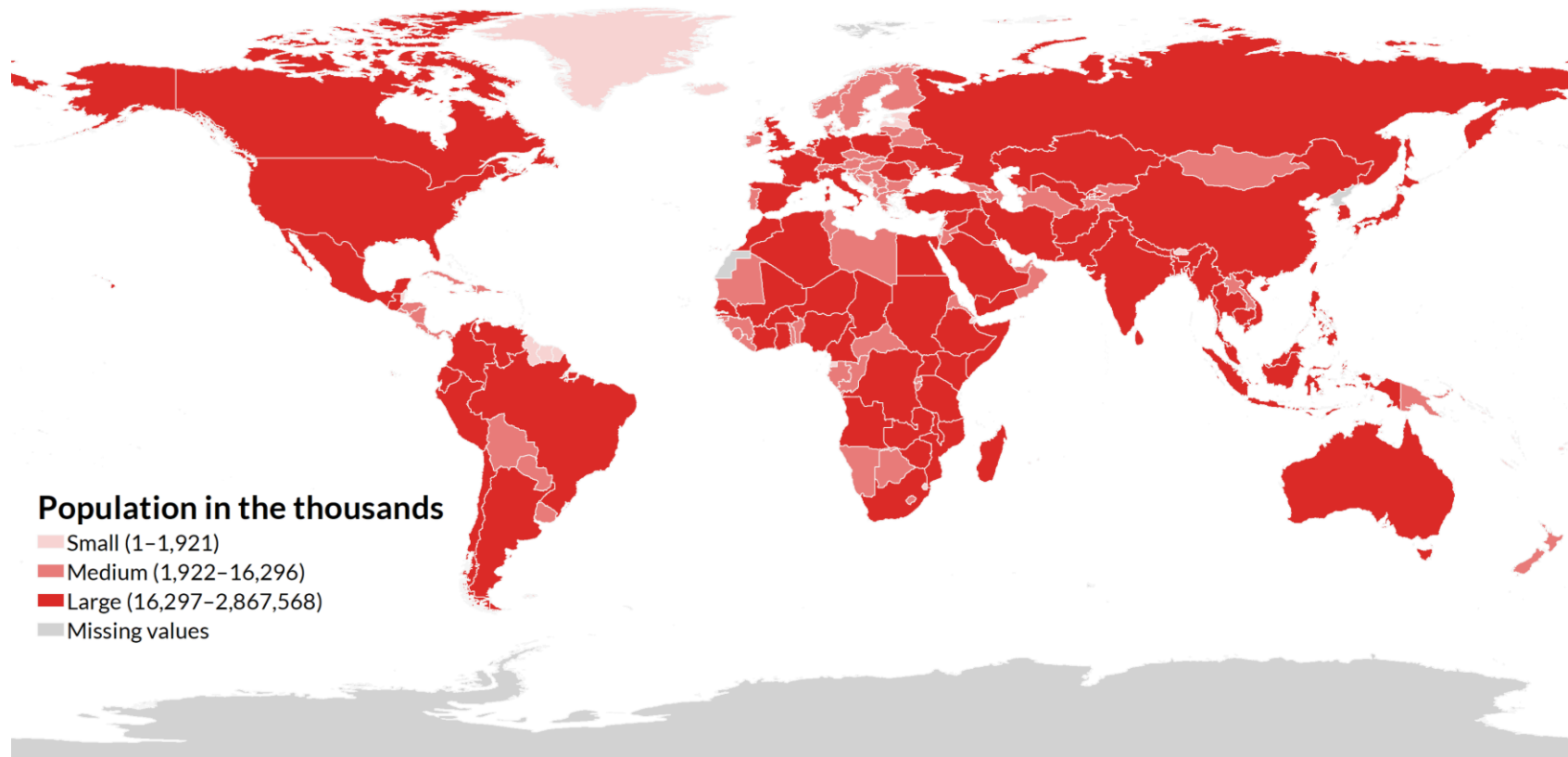


occurred but suggest where future ones might emerge—particularly nations with frequent climate-induced shocks and subsequent displacement. General migration rates (figure 6) provided a more longitudinal snapshot into that recurrence.

Finally, focusing on the interconnected nature of social vulnerability and shock exposures helps us define overall risks to real and economic assets (figure 7), to overall well-being (figure 8), and to existing resilience capabilities (figure 9) by nation. These maps are reproduced from pioneering data estimates in the World Bank that foreground the importance of prioritizing the lower-resourced households in developing contexts. Ultimately, affirming these communities as the most critical recipients of and participants in global resilience building is part of an explicit global call to action (Global Commission on Adaptation 2019).

FIGURE 1

National Populations, 2019

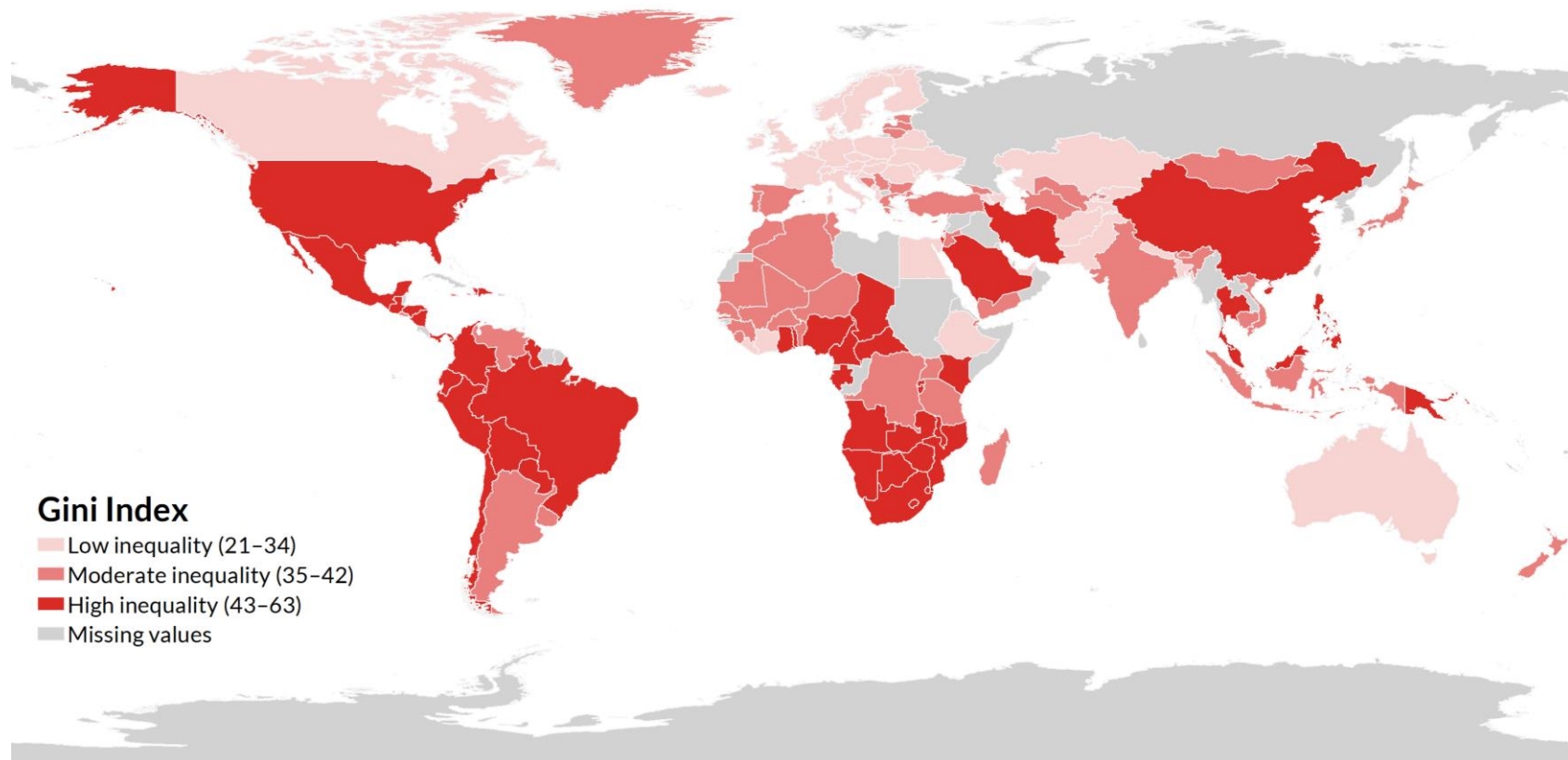


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Source: "Total Population—Both Sexes," United Nations, accessed April 1, 2020, <https://population.un.org/wpp/Download/Standard/Population/>.

FIGURE 2

Inequality in Household Income Distribution (most recent tabulation from 1995-2017)

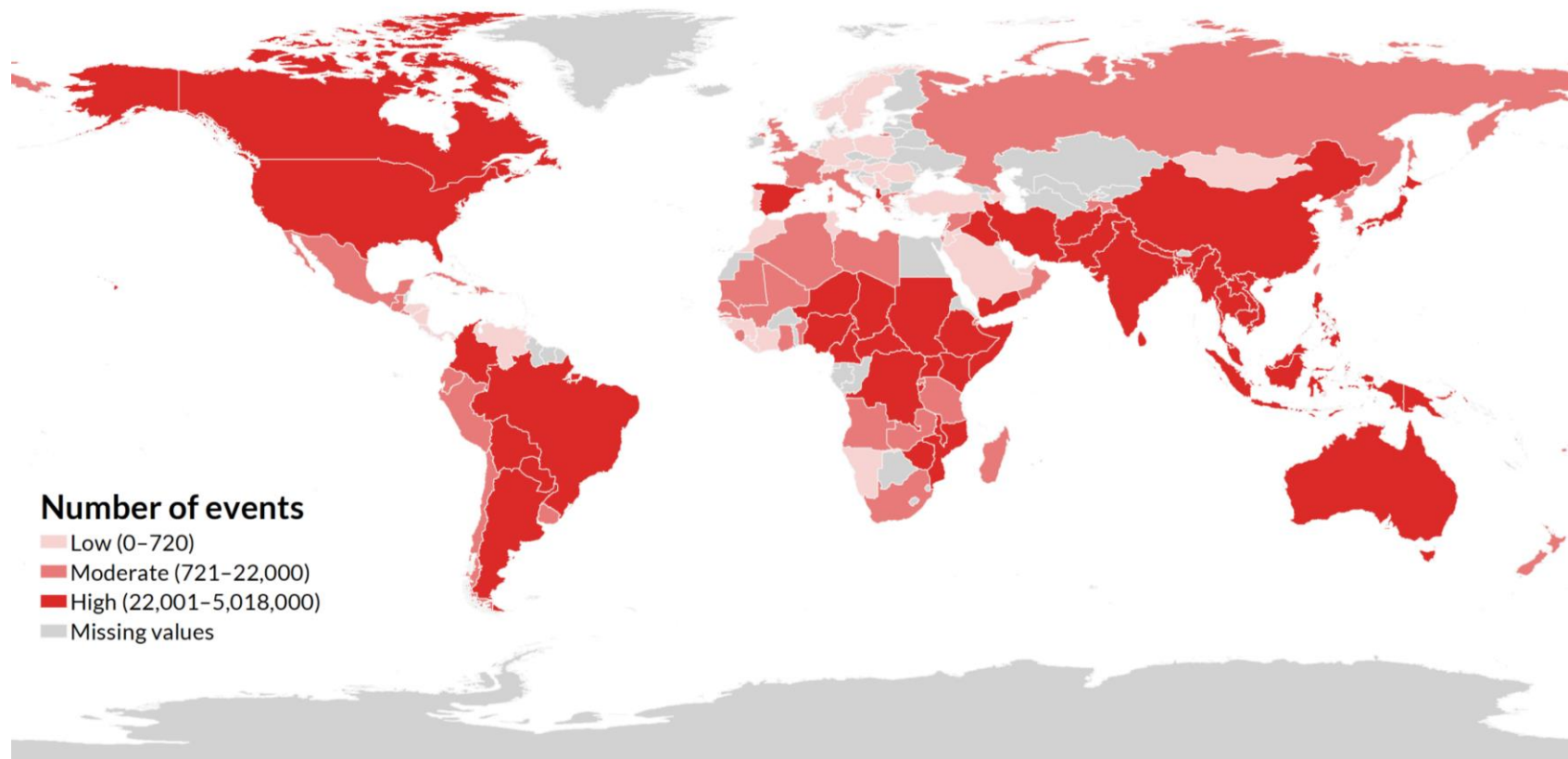


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Source: "Country Comparison: Distribution of Family Income—Gini Index," Central Intelligence Agency, accessed April 1, 2020, <https://www.cia.gov/library/publications/the-world-factbook/rankorder/2172rank.html>.

FIGURE 3

Number of Displacing Disasters, 2019

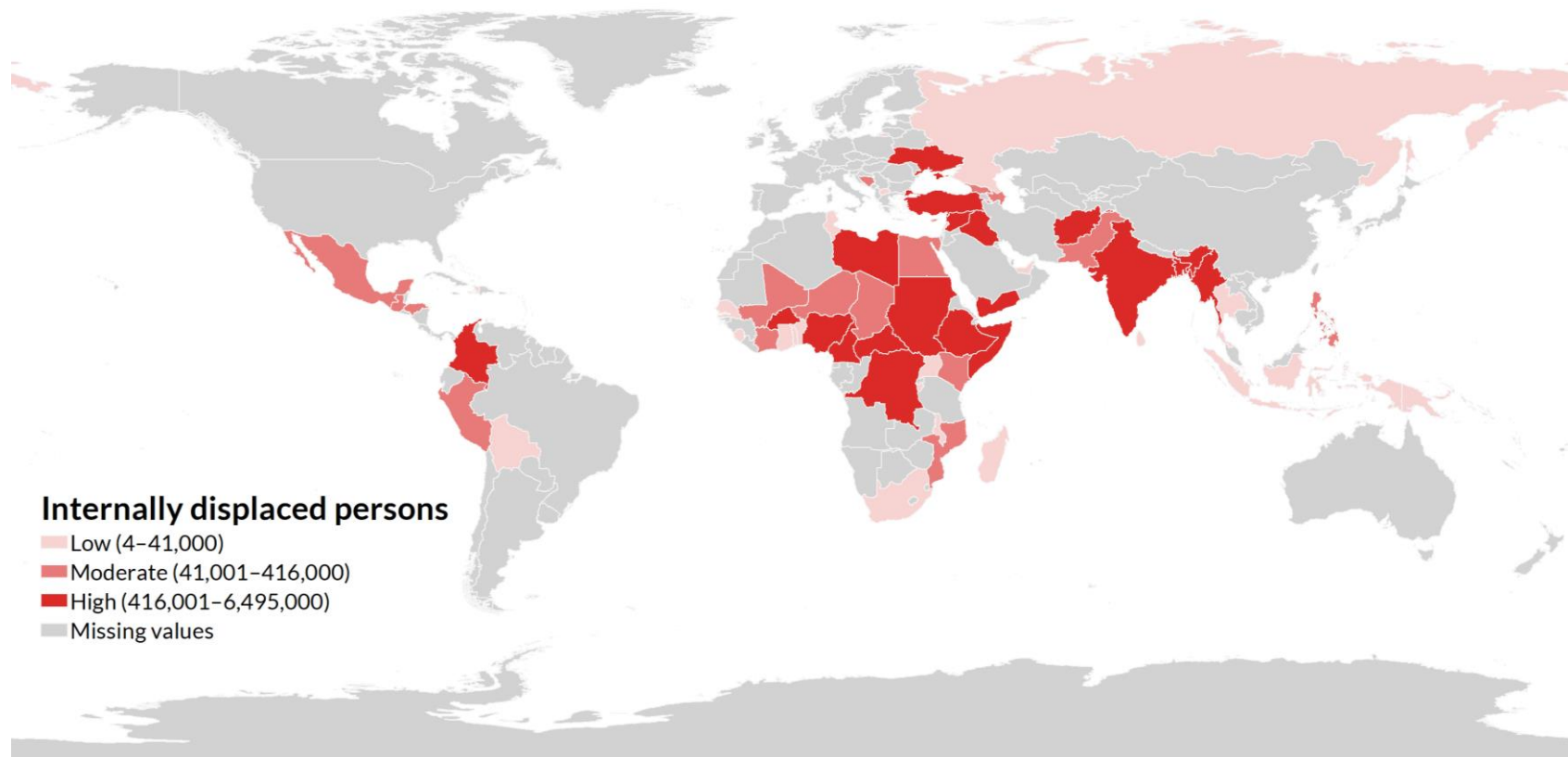


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Source: “2019 Internal Displacement Figures by Country,” Internal Displacement Monitoring Centre, accessed April 1, 2020, <https://www.internal-displacement.org/database/displacement-data>.

FIGURE 4

Total Displaced People per Nation, 2019

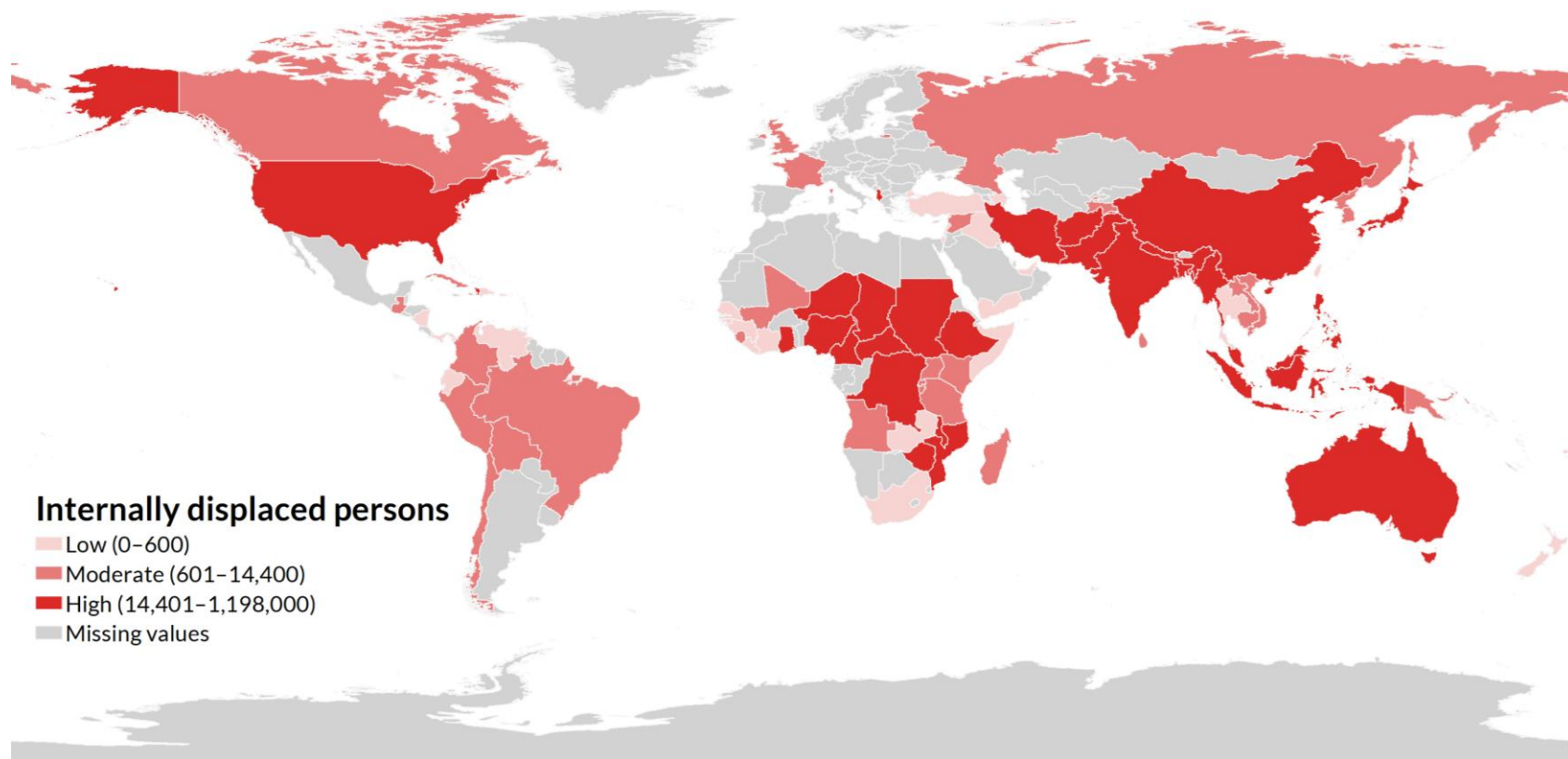


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Source: "2019 Internal Displacement Figures by Country," Internal Displacement Monitoring Centre, accessed April 1, 2020, <https://www.internal-displacement.org/database/displacement-data>.

FIGURE 5

Total Disaster-Displaced People per Nation, 2019

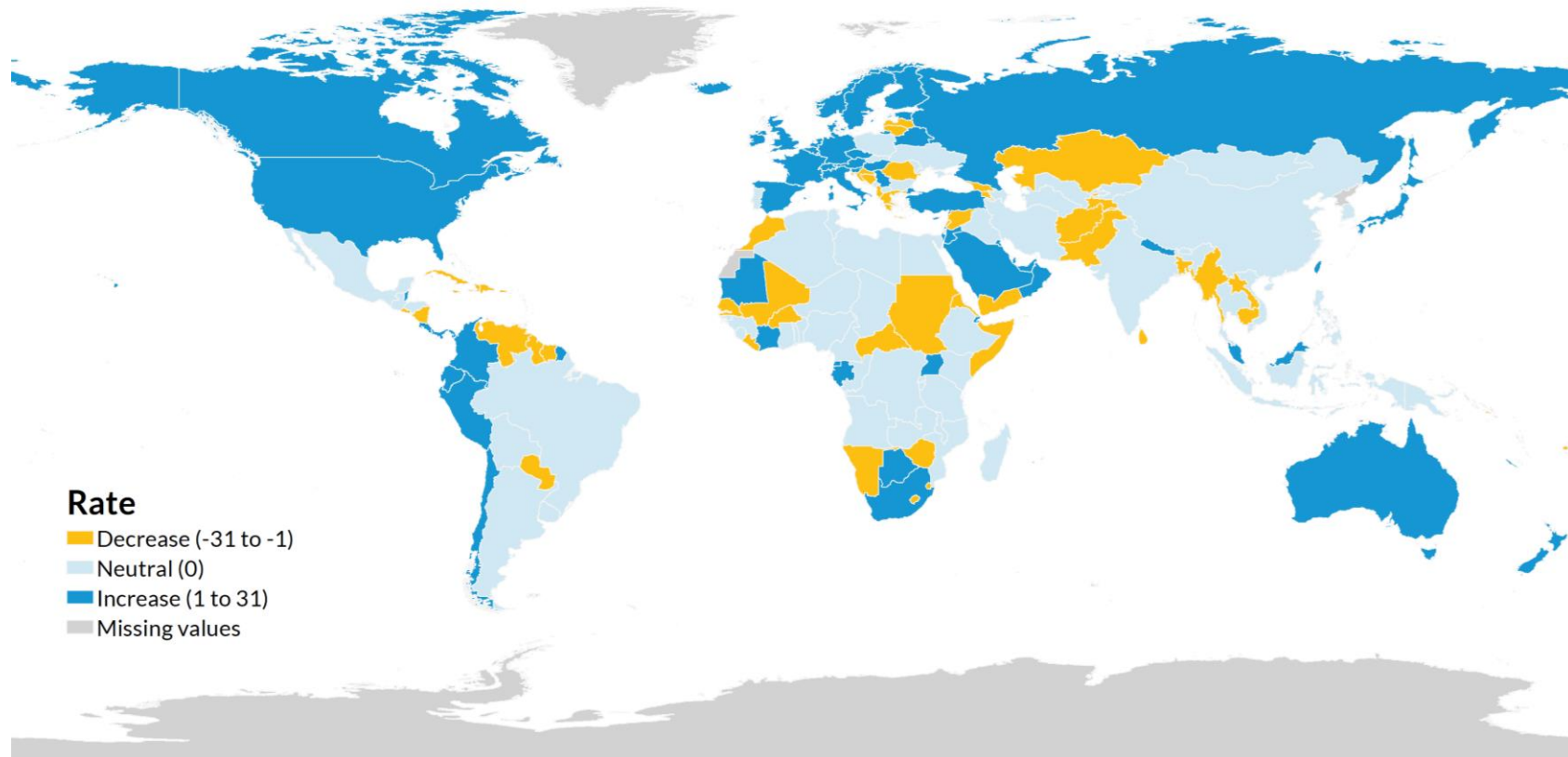


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Source: "2019 Internal Displacement Figures by Country," Internal Displacement Monitoring Centre, accessed April 1, 2020, <https://www.internal-displacement.org/database/displacement-data>.

FIGURE 6

General Migration Rates, 2015–20



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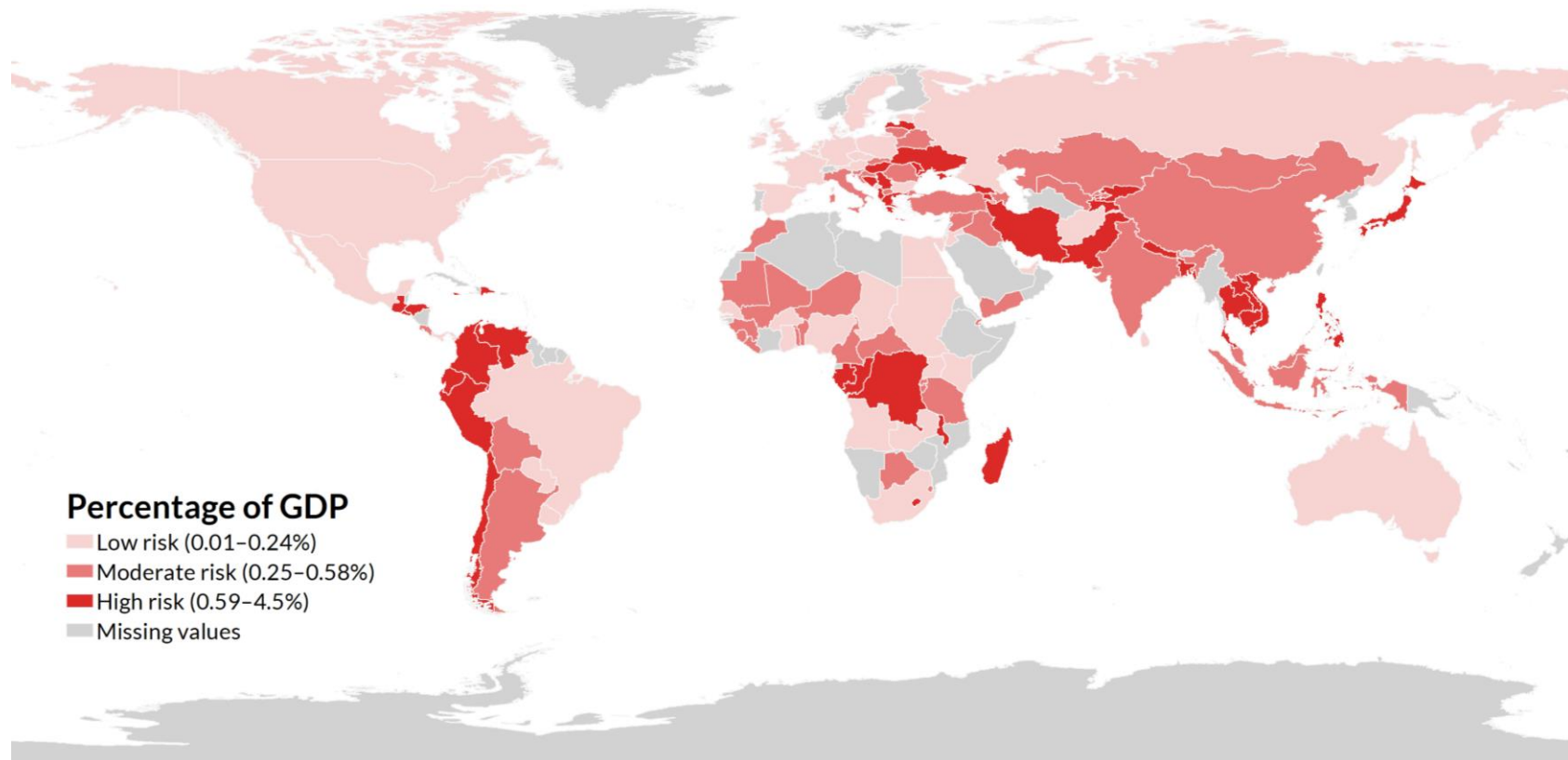
Source: United Nations, accessed April 1, 2020, <https://population.un.org/wpp/Download/Standard/Migration/>.

Note: Net migration rate only.



FIGURE 7

Disaster Risks to Assets, 2017



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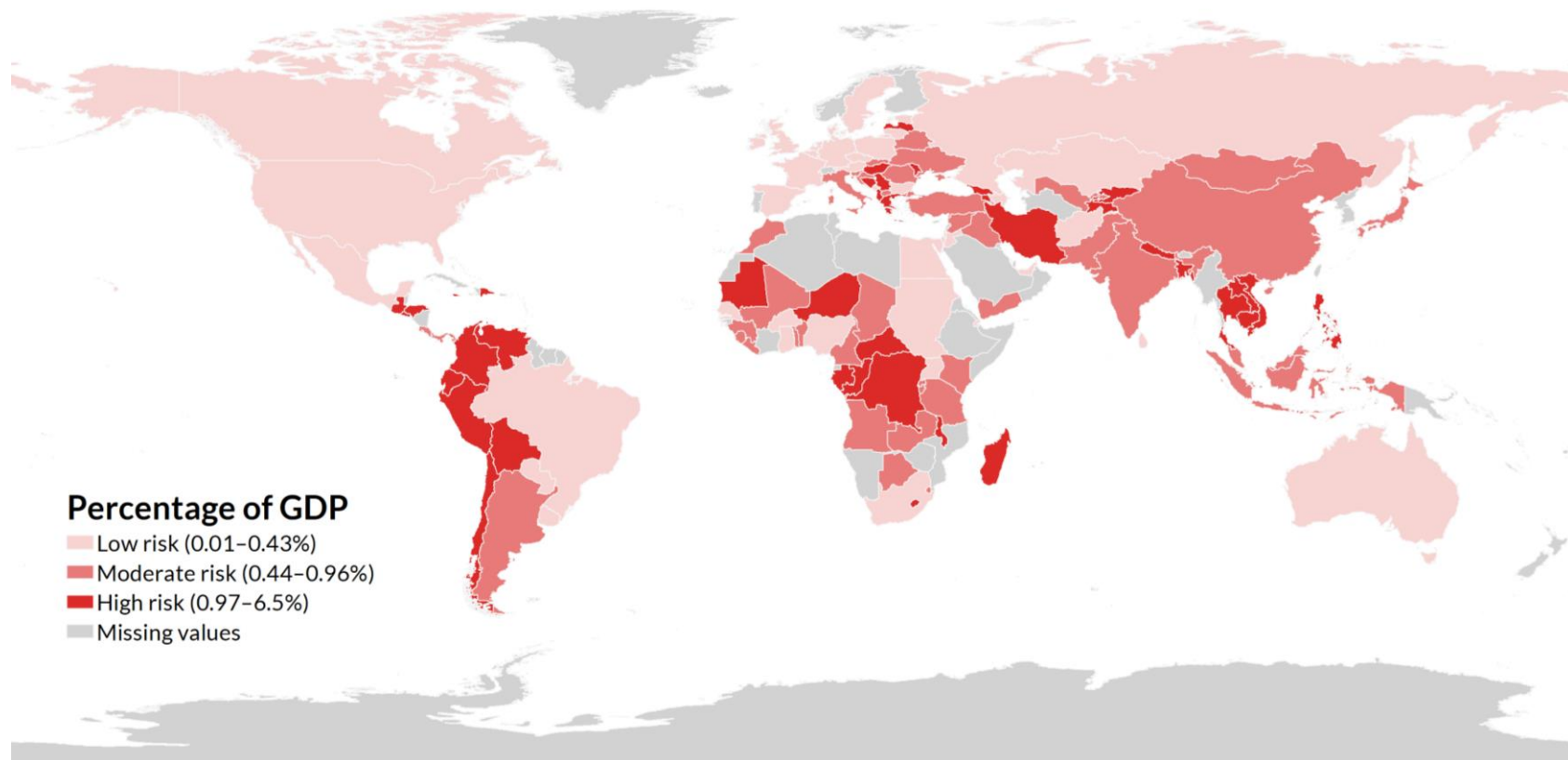
**Source:** Stephane Hallegatte, Adrien Vogt-Schilb, Mook Bangalore, and Julie Rozenberg, *Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters* (Washington, DC: World Bank Group, 2017).

**Note:** Risk to assets is defined as the average monetary value of the total damages that disasters inflict on assets (often measured as replacement or repair value), or the hazard probability x asset exposure x asset vulnerability.



FIGURE 8

Disaster Risks to Well-Being, 2017



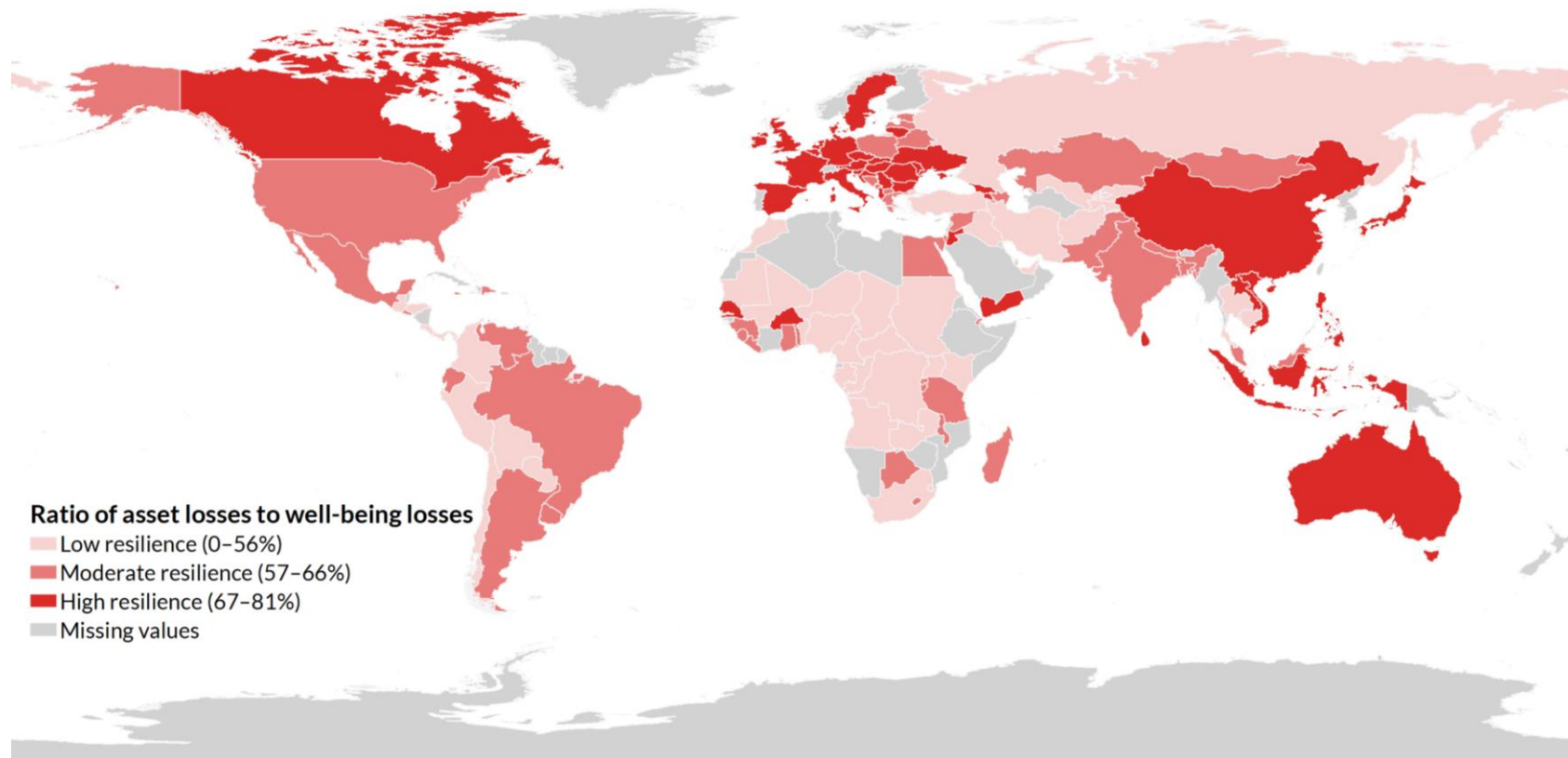
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Source: Stephane Hallegatte, Adrien Vogt-Schilb, Mook Bangalore, and Julie Rozenberg, *Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters* (Washington, DC: World Bank Group, 2017).

Note: Well-being is defined in terms of distributional impacts between the wealthiest and poorest of a nation's population, and well-being losses are the decrease in overall consumption.

FIGURE 9

Resilience Factors, 2017



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**Source:** Stephane Hallegatte, Adrien Vogt-Schilb, Mook Bangalore, and Julie Rozenberg, *Unbreakable: Building the Resilience of the Poor in the Face of Natural Disasters* (Washington, DC: World Bank Group, 2017).

**Note:** Resilience is defined as the ability to minimize the impact of asset losses on well-being. It is measured as the ratio of asset losses to well-being losses and expressed as a percentage of the well-being losses.

## Report Structure

The report uses a consistent format to present the above analysis for each of the six action areas. Each chapter has the following elements:

- a summary of the categories of actions within the area and a review of how the area was selected in the April 2019 survey
- a review of overall need or demand for the action area—that is, the resilience “challenge” that the area’s actions purportedly address
- a description of the literature reviews developed for each action area, with an emphasis on the most recent literature (i.e., the past two years) and those referencing specific interventions or policies
- a summary of the opportunities presented in the literature, including both conceptual scopes for opportunities and strategies for complementing currently active opportunities (This summary includes both the opportunities gleaned from the literature and ones that were explicitly named during outreach to practitioners.)
- brief statements on the likely unit of intervention and its potential scale for each category of opportunity (These statements are provided to clarify the likely scope of the intervention—for example, microinsurance for millions of households in middle-income nations. Individual counts of possible opportunity “markets” are not tabulated as these depend on the depth of the opportunity to be selected.)
- maps produced from the data collections and tabulations that suggest where an opportunity may best be targeted (e.g., middle-income nations exposed to the most severe land losses or risks to property damages)
- brief summaries of the current need and opportunity supply for each area

General recommendations for pursuing the opportunities, including ones explicitly derived from external thought leaders, are summarized in the concluding chapter.

# Community Infrastructure

Physical interventions that protect communities, that create system redundancies for basic services such as electricity and water, and that can withstand or mitigate future shocks are often the first activities that come to mind when resilience is mentioned. Common examples of resilient infrastructure for protections are flood defenses, including both traditional gray responses such as seawalls and green, nature-based solutions such as wetlands. Decentralized, on-site renewables are frequently mentioned as a solution for energy gaps or discontinuities. Storm water retention and increased urban tree canopies are increasingly implemented shock mitigations. The design, construction, and maintenance of appropriate defensive infrastructure, adaptive changes to the built environment, and revision to land uses are often referred to as “structural” adaptation actions (IPCC 2014).

The resilience movement has sought to expand the quantity of new and existing infrastructure that can protect communities, reduce the losses from shocks of all kinds (and avoid them altogether if possible) while providing other social and environmental benefits, and share costs and risks collectively among neighbors, neighboring communities, and regions.

## The Challenge

Shocks of all kinds, such as natural hazards and the chronic effects related to global climate change, will continue to hit all places on the planet. Urbanized areas, and the vulnerable communities within them, will bear the brunt of their impact. Consequently, calls for better and more infrastructure to reduce the shocks’ effects on people, ecosystems, and economies have grown. However, existing infrastructure and practices for building new infrastructure are woefully outdated in relation to future environmental and population needs. Communities that are physically closest to infrastructure facilities (e.g., levees and seawalls) are in immediate danger, while broader populations and economies served by antiquated infrastructure (including transportation, water, and electrical distribution) are also increasingly at risk. Entirely new infrastructure (e.g., cooling shelters and greenspaces) is also needed.

Despite their dominance in resilience plans, the criteria for and decisions to pursue these interventions are still in flux. The range of recent recommendations for addressing this need have been repeated at all scales of place and government, from frontline communities to multilateral entities. Many of the suggested solutions are obvious yet still unaddressed: expanded funding, improved and accurate risk and exposure science, and transparent provision of those data and findings to private

actors (Hallegatte et al. 2019a). Because the majority of engineered and ecosystem interventions are by their very nature place-based, costly, and time-intensive, the quantity of individual interventions is massive (Blanco et al. 2009; Koetse and Rietveld 2012; Ranger and Garbett-Shiels 2012).

Consequently, Urban's researchers sought out opportunities for early interventions that could guide and expedite any potential infrastructure intervention rather than directly resourcing its individual planning, construction, and maintenance. These interventions, grouped into three categories, serve as platforms, tools, and decisionmaking aides that can be used in varied contexts but with the singular goal of improving the resilience capacity of community infrastructure.

- **Design and maintenance “resilience” standards**, or the passage of state or national policies and multilateral or funder guidelines that support construction standards that account for future climate risks. Standards ranging from building codes to minimal flood protections are often used to ensure consistent protections for human settlement, including potential protections for low-income or environmentally vulnerable populations (Biderman et al. 2008; Bartlett et al. 2009; Satterthwaite and Dodman 2009). Ultimately, in the same way that nations and cities have explored standards for climate mitigation through energy efficiency and denser development (World Bank 2012), jurisdictional development requirements, funding criteria, and related standard-setting specifications for climate adaptation projections could significantly alter the fate of large numbers of people with a singular policy change. Partnering with global design, engineering, development, and environmental organizations to determine appropriate standards could give local professional and climate advocates the tools to change this fundamental starting block of resilience.

However, the challenge with such standards and related development regulations is two-fold: (1) they do not traditionally address existing, already constructed infrastructure, which may be the most vulnerable; and (2) they often add costs to development for public works agencies, which are typically strapped for resources and, consequently, become fodder in political and budgetary battles.

- **Cost-benefit analysis innovations**. Because of the inability to monetize all benefits from loss risk reductions, few climate infrastructure projects pan out. Additional “hard” costs to respond to climate adaptation would result, in theory, in much greater benefits such as reduced flood risks (Multihazard Mitigation Council 2018). The need to monetize the value of natural water systems and avoided losses is a financing requirement that has plagued infrastructure in the developed world for decades and one to which additional collaboration and knowledge can yield potential benefits for all future projects (UNFCCC 2011).

Cost-benefit analysis innovations have showed positive results on increasing resilience as well. Partners in this space are local and national governments seeking to improve their analyses, the funding multilateral and bilateral organizations that require them, and private infrastructure investors (including public-private infrastructure partners) that seek monetizable returns.

- **Regional collaboration** and governance to optimize adaptation infrastructure rather than rely on individual city adaptations. An additional challenge to efficient infrastructure design has been the reluctance of jurisdictions to consider regional actions that extend across their geographic boundaries. This governance challenge results in inefficient choices in physical and structural strategies and compounds the costs and financial resources to pay for those strategies (UNISDR 2015).

Activities within this intervention could involve defining public-sector and private property rights (including tenure issues for informal settlements) as well as conserving natural areas and ecosystem services while minimizing and distributing the “hard” costs. Regional infrastructure collaborations could foster cross-jurisdictional goodwill that results in security benefits later (IPCC 2014). For example, improved multilateral governance even at the local or regional level could soften the blows of migration patterns (Atlantic Council 2017).

A notable example of these collaborations is the Southeast Florida Regional Climate Change Compact (Georgetown Climate Center 2017). Similar partners could include regional governmental entities, but also state and national governments seeking to overcome local funding and turf battles.

## The Evidence

Urban researchers explored these three intervention categories through literature and practice reviews and interviews with thought leaders, who corroborated the overall categories, provided updates on unpublished work, and suggested opportunities.

### Resilience Standards for Infrastructure Design, Maintenance, and Approvals

Urban identified several dozen recent monographs that support “resilience standards.” The majority were policy analyses and advocacy monographs that were published in peer-reviewed journals or by standardizing organizations such as the US Green Building Council, Standards Council of Canada, and ISO. The monographs describe updated design and maintenance resilience structures or the

collaborations between local, subnational, national, and regional coalitions to determine these standards. Standards such as building codes, flood protections, and water/wastewater management best practices protect human populations, and several efforts have been tracking and comparing them (Scussolini et al. 2016). When traditional standards do not address existing infrastructure, additional standards regarding maintenance and retrofit may be used to ensure that current and future built and natural environments are appropriately hardened for climate impacts (OECD 2018).

The literature straightforwardly calls for “getting the basics rights,” particularly the governance of infrastructure management and decisionmaking (Hallegatte et al. 2019a). The basics start with fundamental regulations, technical standards, and codes for designing and building infrastructure matched to the likely risks (Bendito et al. 2016). Building standards are generally promulgated by national public or private entities and are often adopted and enforced at subnational levels—at varying levels of rigor (Moullier and Krimgold 2015; World Bank 2017). A few regional exceptions have emerged (Caverzan and Solomos 2014), although these remain largely conceptual agreements. International coordination, such as the International Organization for Standardization and the European Committee on Standardization, helps generate consensus standards that are voluntarily referenced in national codes (NISI n.d.; ISO 2019). However, the range and depth of these standards vary widely, and they are not consistently updated with the latest scientific and engineering information for specific shocks (Nipa et al. 2019). They are also rarely tied to economic analysis that accounts for future conditions (Eijgenraam et al. 2014) and are often prescriptive rather than performance-based—meaning that alternative technologies or even whole categories of infrastructure such as green infrastructure may not be permitted (Kaluvarachchi 2019).

Analogous strategy to resilience standards are sustainable or green building standards, which have emerged over the past three decades in the Global North and have since been promulgated in other contexts, although largely for commercial and residential buildings (World Wildlife Federation 2017).<sup>1</sup> Consequently, organizations like RELi, ENVISION, and FORTIFIED have promoted voluntary resilience standards for buildings, and engineering scholars have posited possible alternatives (Pyke et al. 2012; Meister Consultants Group 2017; Karamouz 2019; Kim et al. 2019; NIST 2019; USGBC 2019).<sup>2</sup>

Meanwhile, many governments have formalized their own standards for infrastructure or facilities (DoD 2012)—for example, the 2015 Federal Flood Risk Management Standard in the US (it has since been rescinded). The World Bank has announced plans to develop resilience metrics or an adaptation rating system from which to review its work (World Bank 2019). And private and semiprivate infrastructure providers have speculated about resilience standards or, alternatively, comparison

metrics for assessing resilience infrastructure as a de facto standardization process (Ewing 2015; Tonn et al. 2020).

Ultimately, three gaps remain. First, no global consensus exists on technical and economic standards (Larsen et al. 2011), and governmental and multilateral decisions about the level of engineering performance required of infrastructure that can protect millions of households tend to be made piecemeal. Second, even though recent resilience standards may consider life-cycle costs and long-term maintenance and operations, they do so only for new infrastructure. Decisions on upgrading and maintaining existing infrastructure to prepare for new shocks (including standards for decommissioning older systems) are excluded, rather than anticipated, as part of infrastructure asset management. Consequently, and third, decisions about what level of risk existing infrastructure should be designed to (both acceptable and unacceptable risks) often become political and budgetary, rather than consistent and evidence-based.

In short, the literature suggests that the field of technical standards and decision tools for resilient infrastructure is nascent and could use further research, formalization, dissemination, and advocacy across political and geographic contexts (Le Cornu 2017).

## **Cost-Benefit Analysis Innovations**

Technical standards for infrastructure design, construction, and maintenance are important because they create a standard on which the hard costs of different infrastructure options can be compared, and the measures for benefits that are not readily monetized. Projects funded by most governments and multilaterals must undergo a cost-effectiveness test (OMB 1992; FEMA 2009; CEQ 2014). Cost-benefit analysis (CBA) is the test of choice and is helpful from a policy perspective because it requires articulation and measurement of both practical costs and aspirational benefits (Arcadis 2012; Shreve and Kelman 2014).

The science of CBA has advanced as more governments and investors require them. The assessments have done a better job valuing the impact that projects will have on local economies and ecosystem services at a granular level (Gramlich 1981; Arnold 1988; Boardman et al. 2017). For flood mitigation, for example, CBAs now integrate sophisticated risk exposure that can estimate detailed property and business losses in the absence of proposed defenses (Economist 2016). Yet, the quantification of all costs for any infrastructure project (e.g., regulatory compliance, community engagement, and alternative procurement) and all benefits (e.g., social capital and loss avoidance) is still elusive. In virtually all empirical cases, though, the benefits of resilient infrastructure outweigh its costs



(Mechler 2016; Hallegatte et al. 2019b). Regardless, the jury remains out on whether CBAs suitably depict costs and benefits from all stakeholders' perspectives and whether costs and benefits are realized beyond the project approval stage.

Bluntly, resilience complicates CBAs. Proponents of resilience perspectives argue that investments must be predicated on fully inclusive engagement with communities for governments and investors to comprehensively identify all impacts and “co-benefits,” or the multiple loss-avoidance, social, economic, and environmental benefits gained from the holistic planning and long-term vision of resilience advocates. Resilience investment, then, is more expensive than a traditional hazard mitigation project because of the holistic survey and community-centered processes. However, resilience should yield more—and larger magnitude—benefits than its counterparts, which are solely framed as hazard mitigation efforts. This paradigm shift leaves fundamental questions: Does resilience building pay off for communities? Do public and private investments benefit the nation's flood-vulnerable, low- and moderate-income groups?

The researchers identified 20 recent, relevant publications—advocacy monographs, case studies, policy analyses, and scholarly exploratory studies published in peer-reviewed journals or by institutions like NIST and the OECD—that focus on how to monetize the benefits of hardened climate infrastructure. Local, national, and regional governments can use these methods to improve analyses of built infrastructure and to encourage private outfits to invest in infrastructure that will provide monetary returns.

Although many recent monographs have explored hazard mitigation and climate adaptation infrastructure as a way to avoid losses (Dong et al. 2015; Hirte et al. 2018; Duan et al. 2019; Liu et al. 2019; Zhang et al. 2019), they tend to focus on economic losses to property alone. Equity considerations in CBAs remain unsolved (Hallegatte et al. 2019). However, several infrastructure investment facilities have proposed “resilience screens” that integrate social benefits, including procedural inclusion and outcome equity (Kind et al. 2019). These co-benefits have surfaced in numerous philanthropic and public resilience efforts (Helgeson and Orear 2018) and are also referred to as societal CBAs or multicriteria analyses (Hudson and Botzen 2019). These wider approaches allow ecosystem services and related environmental benefits to be introduced more squarely in cost justifications (Alves et al. 2019).

CBA needs more advances, and CBAs need to be disseminated and consistently written in to public, multilateral, and private investment planning.

## Regional Collaboration and Governance

Infrastructure that protects communities against future shocks can be planned more efficiently and made to be more effective when governments work together at scales appropriate to the possible shocks and stressors. Flood exposure, for example, does not stop at one city's borders. A “whole of government” approach to infrastructure development depends on the capacity of jurisdictions that share environmental conditions—such as a metropolitan region or neighboring cities—and their ability to collaborate, plan, and share the costs and benefits of infrastructure. These efforts can cross both geographic and sectoral boundaries—for example, by integrating water and energy utilities with political jurisdictions (Hallegatte et al. 2019). These collaborations are often managed through a new administrative body (such as a regional council or association) that conducts research, develops consensus, and even issues shared finance.

The research team identified 22 recent, relevant monographs—primarily case studies, policy analyses, and advocacy monographs published in peer-reviewed journals or by institutions like the OECD and the World Bank—that focus on new approaches to regional climate resilience collaboration. Collectively, this work suggests that collaboration has been a challenge, resulting in some inefficient decisionmaking on physical and structural strategies as individual cities go their own way. The scholarship argues that regional collaborations could help match engineering solutions to environmental hazards, particularly when they include public and private sector engagement (property right declarations, conservation decrees, compacts) and civil-sector partners (Hoff et al. 2020).

Developing countries often have fewer subnational governments and more centralized national authorities than developed countries, so regional collaboration may not be as relevant for efficient infrastructure planning and development in those contexts unless the nations in question are geographically small. In that case, international collaborations like those in the Caribbean or Western Europe may be reasonable (OECD 2012). In these cases, risk management innovations through institutional arrangement can help engage all stakeholders (OECD 2014). Several studies describe the diversity of arrangements, including different combinations of public and private actors (Nagel et al. 2019). Others focus on the need for coordination among subnational entities in the absence of national guidance (Juhola, Haanpää, and Peltonen 2012; Di Gregorio et al. 2019).

Recent scholarship is replete with calls for such arrangements in various contexts (Duit et al. 2010; Westerhoff et al. 2011; Juhola, Peltonen, and Niemi 2012; Dewulf et al. 2015). However, examples of such arrangements are few, and evaluations of their implementation, efficiency, or effectiveness are even fewer (Forsyth 2010; Dieperink et al. 2016; Addie et al. 2019). Indeed, more attention has been

paid to conflict and tension resulting from such arrangements or to external actors (such as multilaterals or higher levels of government) than to actualized infrastructure projects (Heijden et al. 2019). Despite the challenges, most studies say an expansion of regional collaborations is a necessary ingredient of resilient infrastructure development.

## The Opportunity

As a nascent sector, resilient infrastructure leaves too few realized projects to provide conclusive evidence for selecting paths forward. Yet the review of these three action areas reveals several current practices and activities with promise that have not been fully realized and for which most scholars and professionals agree there is room to grow. There are key opportunities to explore and seed.

For example, having decisionmaking tools for commissioning, upgrading, and decommissioning infrastructure in ways that are scientifically accurate, economically sound, and politically feasible across the geography of at-risk communities can create a platform and universal knowledge base to adapt to future conditions. This starts with appropriate building standards and decision criteria for green-lighting infrastructure along the lines of institutional standards (such as ISO, CEN, and the World Bank's proposed resilience metrics rating system) and voluntary technical guides (like RELi and FORTIFIED). Yet it also includes expanding the technical and enforcement capacities of national and subnational governments to ensure that these standards are realized, particularly in nations with minimal code enforcement authority and extensive informal settlement. Current plans under way by multilateral organizations are

- the World Bank's "Building Regulation for Resilience" program;
- the global Coalition for Disaster Resilient Infrastructure sponsored by the Indian government and its goals for developing standard and certification processes;
- the UK-organized Coalition for Climate Resilient Investment;
- environmental organizations' nascent resilience project preparation programs, particularly for infrastructure that improves ecosystems and related nature-based green projects;
- various national efforts for building resilience standards, such as the International Code Council's Alliance for National and Community Resilience in the US.

These early efforts may provide numerous opportunities for supporting test cases and demonstrations (World Bank 2020). As the demise of FFRMS notes, however, consistent technical

standards and decision tools are only as good as the institutional supports. Advocacy strategies and incentive programs could be put toward encouraging nations and regions to adopt and enforce standards in regulations of private structures, and to consistently use them for publicly-funded ones.

Regarding cost-benefit analysis, most current opportunities come in the realm of speculative research by infrastructure economists and philanthropic entities looking to refine tools for monetizing infrastructure effects, particularly about social outcomes like equitable distribution of benefits. Private entities in infrastructure finance are also testing “resilience screens” that could benefit from further expert elaboration and piloting and, where implemented, ex post facto evaluations of the accuracy of the original cost-benefit calculations. The following are samples of these efforts:

- explorations of equity investment measurement efforts by the Kresge Foundation and the Miami Foundation
- assessments of public-sector investments that required resilience-specific CBAs already in place, such as specific projects supported by the global Adaptation Fund; national efforts from the US, including Rebuild by Design, the National Disaster Resilience Competition, and Building Resilient Infrastructure and Communities; and efforts from cities, such as Miami’s Miami Forever resilience bond-funded projects (Considering the evidence base across sectors and countries could also help prove the global case that preventive measures and resilience screens are more cost-effective than rebuilding after shocks, as noted by one thought leader interviewed for this study.)
- development and demonstrations of private and multilateral resilience screens, such as the Rockefeller Foundation’s Urban Resilience Fund, the Urban Climate Change Resilience Trust Fund (with USAID, UK DFID, and the Asian Development Bank), and the range of new fund efforts described in the next action area

Finally, the lessons learned to date from multicity regional collaborations like the Southeast Florida Regional Climate Change Compact suggest many opportunities to bolster consensus-building efforts to align funding and policy in existing collaborations, as well as opportunities to seed new ones in different contexts where interjurisdictional siloes continue to prohibit the development of the most efficient infrastructure investments. Organizations like the National Association of Regional Councils have supported such organizational efforts, while other professional associations such as the Urban Sustainability Directors Network, ICLEI, and the recently created Global Resilience Cities Network could support the sharing of best practices globally. Where constitutionally relevant, building state and other subnational-level capacities to coordinate “resilience regions” that can pool resources and design

effective resilience-building strategies and infrastructure collaboratively. These efforts would be particularly relevant in regions with a high proportion of subnational governments per capita.

An expert interviewed for this study noted that the risks that contemporary building codes are designed to protect against are evolving with climate change. As there are no definitive answers on how these risks will manifest, collaboration between climate science and building science communities is needed to devise ways to promote resilience by incorporating evolving risks in building codes and standards processes. Such cross-discipline collaboration is also needed to address extreme heat and cold, with attention to how building codes and energy codes could intersect to create co-benefits.

While there has been some progress in developing benchmarks or tools to measure resilience of infrastructure, future strategies should consider how those benchmarks might shape incentives (positively or negatively) for community investment in infrastructure—especially in cases where assessments based on those benchmarks provide objective measures of need that suggest an alternative allocation of scarce community resources. More broadly, this respondent recommends a holistic view of community resilience that allows for a matching of available resources with critical areas of need, as opposed to overinvesting in certain functions that do little for overall community resilience.

## Unit of Intervention

Because technical standards tend to be managed at the national level of government, the development and advocacy efforts associated with this effort would have to work at the same entry point. Organizations working internationally, however, could help promote best practices.

In contrast, cost-benefit analysis techniques and demonstrations could foreseeably be pursued at an international scale for development but would inherently apply in and need to be tested on individual projects (for example, a single wetlands flood defense project), potentially in the most severely exposed regions with a proportionally large vulnerable population. Because these possible opportunities' implementation is place-based, ensuring that any demonstrations are designed for longer-term learning and dissemination is critical.

Regional collaborations' unit of intervention are, obviously, regions composed of jurisdictions in overlapping ecosystems, social contexts, and economic markets, such as metropolitan areas.

## Scale of Intervention

As noted previously, technical standards and infrastructure decision tools require sufficient capacity for adoption and enforcement. Consequently, these opportunities would need to draw on different strategies for upper-income nations with significant extant capacity (such as extensive advocacy), middle-income ones with varied capacity (technical capacity-building and advocacy), and lower-income nations with limited capacity (extensive capacity-building). Global tabulations of building law rigor by nation could help identify this range in more detail, and overlaid with risk and vulnerability assessments as well as current infrastructure investment levels, could identify the specific nations and populations to be prioritized. The opportunities associated with this category of actions, though, are globally applicable and can be scaled through multilateral funders and organizational supports. The development time frame is speedy (potentially one to two years), but the national advocacy efforts could take longer.

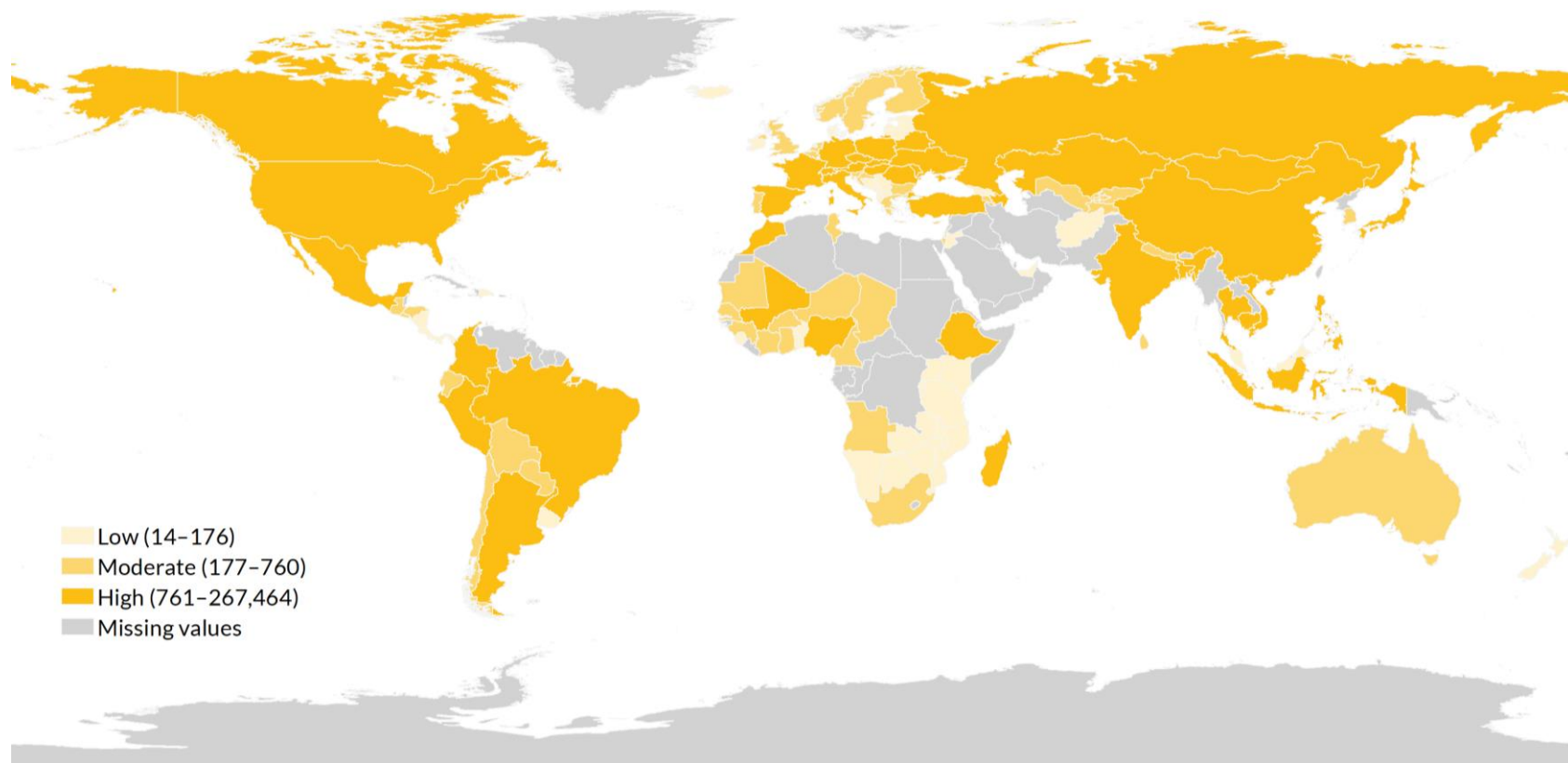
Cost-benefit analysis guidelines are also globally applicable and could be scaled even more quickly by professional associations and funders, but only after evidence of their accuracy and reliability can be produced through demonstrations. Agreements on the analytical methods could be generated in a similarly speedy timeframe as technical standards, but demonstrations would require following actual development projects that may range in timeframe from three years to over a decade depending on the shock in question.

In contrast to the other two action areas, regional collaborations are only relevant where there are governance gaps induced by too many overlapping jurisdictions within the region. In theory, those places with centralized national governments that determine infrastructure standards, make decisions about infrastructure investments, and can coordinate various subnational governments independently could be ideal entry points for the kinds of tools and advocacy opportunities presented in this report. Having significant state or regional governments to coordinate municipal differences could also provide a secondary pool of candidate sites. When looking at concentrations of subnational governments per capita as a proxy for the level of national centralization (figures 10–13), potential regions of influence include several developing countries in Africa, Central America, and the Caribbean but also several developed nations such as Australia, Canada, Chile, and New Zealand.

However, these determinations should be balanced with considerations of developmental priorities (by, for example national income levels, social conditions, or environmental vulnerability) to help define the ultimate implementation scale. For example, a decentralized government with extensive need for resilient infrastructure could be prioritized, but with a higher level of effort and resources appropriate to the task.

FIGURE 10

Number of Subnational Governments by Nation, 2018

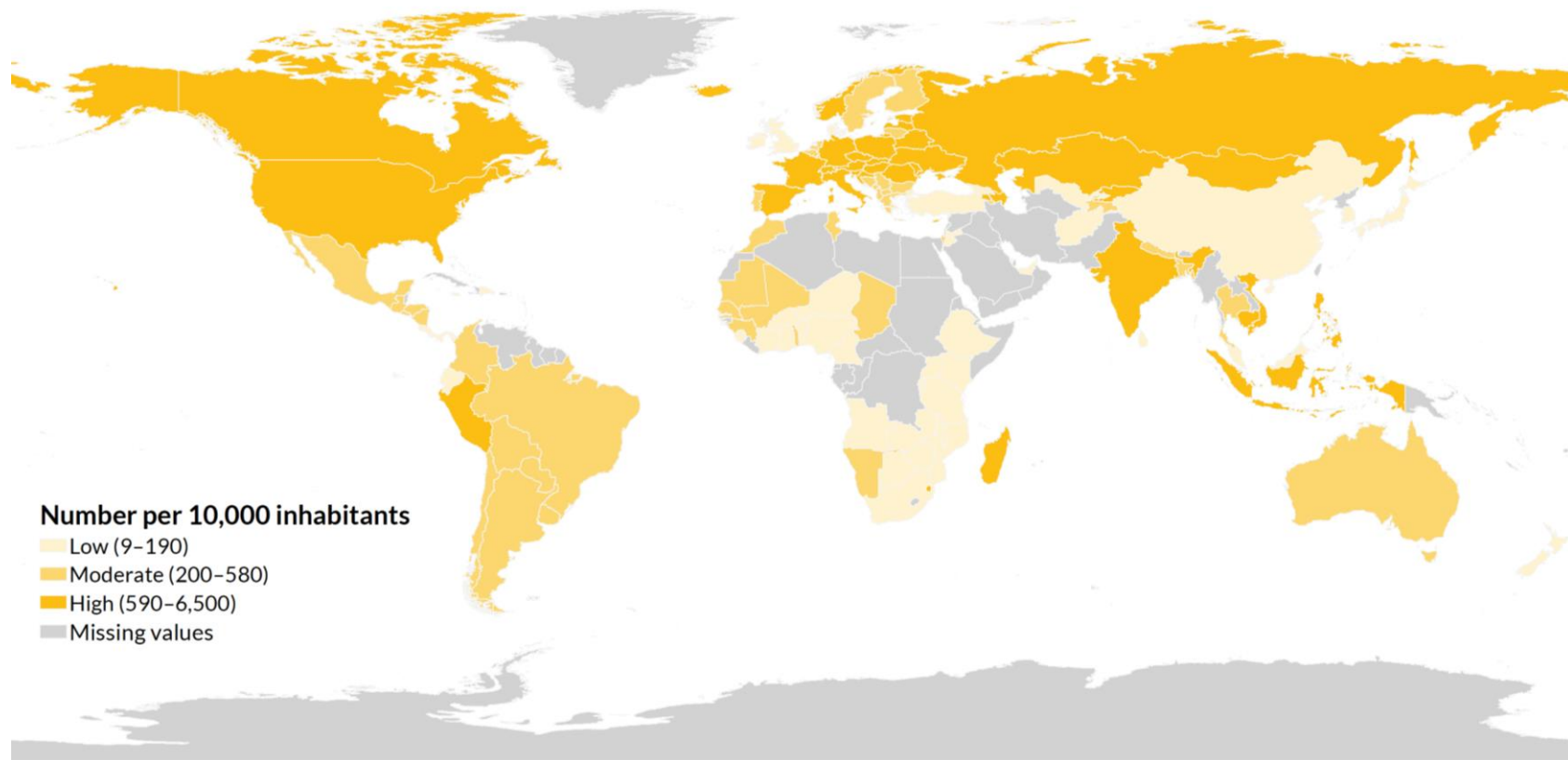


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Source: “OECD-UCLG World Observatory on Subnational Government Finance and Investment,” OECD.Stat, accessed April 1, 2020, [https://stats.oecd.org/viewhtml.aspx?datasetcode=SNGF\\_WO&vh=0000&vf=00&l&il=blank&lang=en&vcq=1111](https://stats.oecd.org/viewhtml.aspx?datasetcode=SNGF_WO&vh=0000&vf=00&l&il=blank&lang=en&vcq=1111).

FIGURE 11

Number of Subnational Governments per 10,000 Inhabitants



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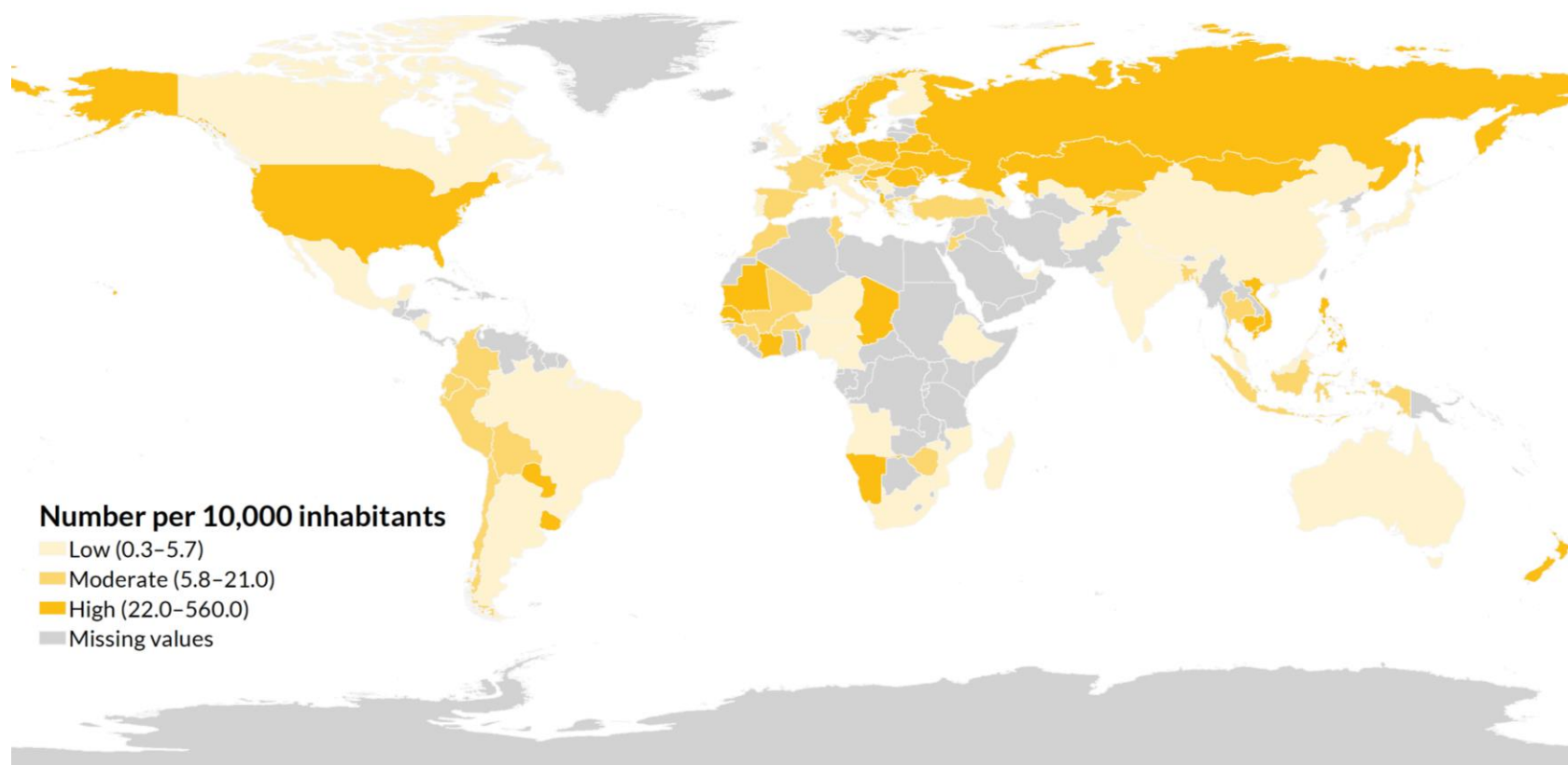
**Sources:** “OECD-UCLG World Observatory on Subnational Government Finance and Investment,” OECD.Stat, accessed April 1, 2020, [https://stats.oecd.org/viewhtml.aspx?datasetcode=SNGF\\_WO&vh=0000&vf=00&l&il=blank&lang=en&vcq=1111](https://stats.oecd.org/viewhtml.aspx?datasetcode=SNGF_WO&vh=0000&vf=00&l&il=blank&lang=en&vcq=1111); “Total Population—Both Sexes,” United Nations, accessed April 1, 2020, <https://population.un.org/wpp/Download/Standard/Population/>.

**Notes:** The subnational government per capita data are for 2018. The population data are for 2019.



FIGURE 12

Number of Regional Subnational Governments per 10,000 Inhabitants



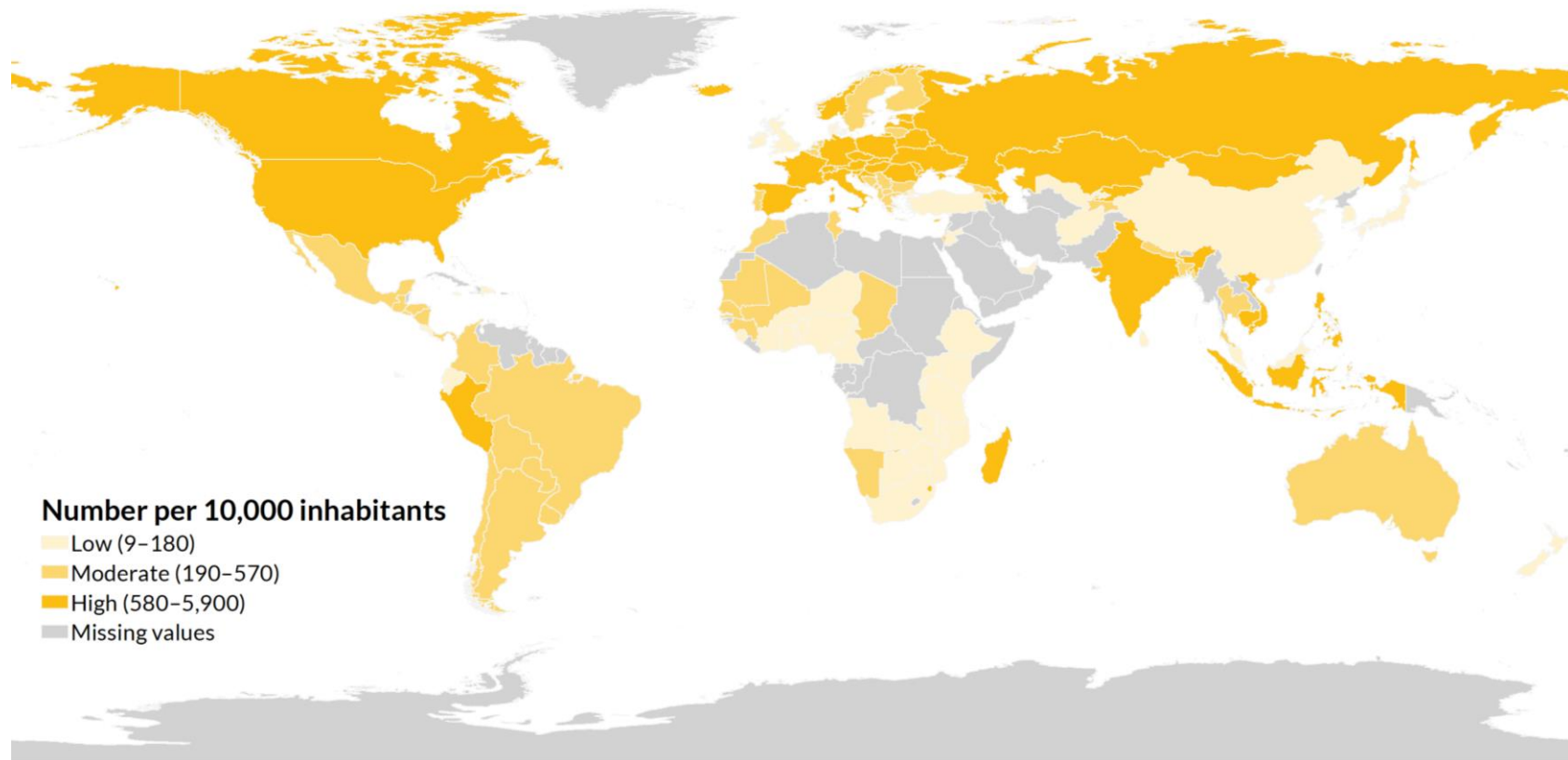
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**Sources:** “OECD-UCLG World Observatory on Subnational Government Finance and Investment,” OECD.Stat, accessed April 1, 2020, [https://stats.oecd.org/viewhtml.aspx?datasetcode=SNGF\\_WO&vh=0000&vf=00&il=blank&lang=en&vcq=1111](https://stats.oecd.org/viewhtml.aspx?datasetcode=SNGF_WO&vh=0000&vf=00&il=blank&lang=en&vcq=1111); “Total Population—Both Sexes,” United Nations, accessed April 1, 2020, <https://population.un.org/wpp/Download/Standard/Population/>.

**Notes:** The subnational government per capita data are for 2018. The population data are for 2019.

FIGURE 13

Number of Municipal Subnational Governments per 10,000 Inhabitants



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**Sources:** “OECD-UCLG World Observatory on Subnational Government Finance and Investment,” OECD.Stat, accessed April 1, 2020, [https://stats.oecd.org/viewhtml.aspx?datasetcode=SNFG\\_WO&vh=0000&vf=00&il=blank&lang=en&vcq=1111](https://stats.oecd.org/viewhtml.aspx?datasetcode=SNFG_WO&vh=0000&vf=00&il=blank&lang=en&vcq=1111); “Total Population—Both Sexes,” United Nations, accessed April 1, 2020, <https://population.un.org/wpp/Download/Standard/Population/>.

**Notes:** The subnational government per capita data are for 2018. The population data are for 2019.

## Summary

The three categories defined in this action area represent a growing area of global interest and activity: community infrastructure that can protect populations from shocks, that can be retrofitted or upgraded to ensure continuity of services and needs like electricity and water during shocks, and that can help prepare collective decisionmaking beforehand. There is preliminary evidence that all the opportunities in these categories may prove particularly helpful in building the resilience of communities' infrastructure globally, though that effect comes to individuals from the longer-term, secondary benefits of being in places that put accurate, thoughtful, and efficient infrastructure in place.

Yet the potential for these efforts is dependent on whether they are sufficiently funded, technically accurate, and politically accepted by

- the national governments that typically manage standards for public works as well as codes and regulations for private infrastructure;
- the multilateral, governments, and private investors for specific infrastructure projects that must be convinced of their individual costs and benefits, including those processes and outcomes that are typically associated with resilience and its complementary social and environmental goals but are difficult to monetize;
- the individual jurisdictions—county and city governments and special districts such as utility territories—that must agree to collaborate in knowledge and resources for the better of their shared regional infrastructure and the state or national governments that may limit or enable such collaboration.

Interventions in all three areas can involve recent efforts in other organizations, particularly those in multilateral organizations that may need additional resources for pilots, development, and professional expertise. However, these partnerships could add time and complexity to the original goals and objectives. Despite the potential challenges and indirect nature of this action area, making infrastructure more resilient is both a critical collective act that can service whole populations of individuals and, in turn, make them more resilient.

# Notes

- <sup>1</sup> Stephanie Vierra, “Green Building Standards and Certification Systems,” updated August 5, 2019, <https://www.wbdg.org/resources/green-building-standards-and-certification-systems#rcas>.
- <sup>2</sup> See “About ENVISION,” Institute for Sustainable Infrastructure, <https://sustainableinfrastructure.org/envision/overview-of-envision/>; and “Fortified,” Insurance Institute for Business and Home Safety, <https://fortifiedhome.org>.

# Public Finance

Another crucial ingredient for community infrastructure, as well as any other resilience-related activities or services, is finance—that is, the appropriation, aggregation, and leveraging of the financial resources necessary to pay for infrastructure, services, and the other material actions needed to adapt. Public finance for major infrastructure and social programs provides an even wider pool of potential strategies because it addresses the core absence of resources, particularly for developing countries and the most vulnerable communities (Brown et al. 2011; OECD 2011). However, the strategies remain speculative even though they are consistently referenced in the literature and among practitioners.

## The Challenge

Very few countries or public entities can fully *fund* (or directly pay for) all the adaptation projects required to respond to the effects of climate change. Therefore, governments need market-based instruments that allow them to *finance* these initiatives (have a third party provide the capital and then pay back the amount with interest). Despite innovations in the development of conduits (e.g., development banks and international funds) and products to finance adaptation (e.g., grants, loans), the underlying mechanics are still those of conventional financing (Keenan, Chu, and Peterson 2018). Investing in climate adaptation is unique, however, in that at the time of investment, quantifying what benefits will be obtained, how long it will take for the benefits to be fully realized, and who will capture the value that these investments generate is complicated (Acton 2019). The challenges are critical across the developing world, but they are acute in countries especially vulnerable to the effects of climate change and whose funding and financing capabilities are limited. This is the case of small island developing states (SIDS), least developed countries (LDCs), and landlocked developing countries.<sup>1</sup>

That capital is not flowing into adaptation projects at the rates required to respond to climate change's challenges is no surprise. The annual, global costs of adaptation are likely to be \$280 to \$500 billion by 2050, but only \$22 billion was invested in 2016 (Mikale, Tonkonogy, and Mazza 2018). Developing countries are focusing on corrective actions (often with international assistance) rather than preventive interventions because of budget constraints and the high costs of early adaptation (Catalano, Forni, and Pezzolla 2020). More and better vehicles for financing climate adaptation need to be explored, spread, and scaled up, particularly in places most at risk of suffering the effects of climate change.

In theory, public finance innovations could fill the finance gap, beyond the multilateral funders such as the Pilot Program for Climate Resilience, the Less Developed Countries Fund, and the Adaptation Fund (Kumamoto and Mills, 2012).

The following are opportunities in this area:

- **Multilateral, national, and state direct investments** and finance facilities. General obligation bonds and other traditional financial system savings and debt mechanisms are often used for infrastructure projects and can leverage investments from private actors, assuming that the government can repay through the project's direct revenue, other monetized benefits, or increased taxes.

However, governments at all levels do not appropriately account for climate change-related risks (including the risks of not acting); current estimates assume that nations need to spend 2 to 3 percent of their GDP annually on adaptation infrastructure (IMF 2019). Pilot public-private finance mechanisms, including risk guarantees, may help expand the finance options for infrastructure development, but much innovation and exploration are needed. Infrastructure revolving loan funds, infrastructure banks, and disaster performance bonds are experiments in developed contexts (Keenan 2018).

- **Specialized bonds** (green, resilience, climate bonds). Use of these financing vehicles has risen in the past decade, but no international standards exist for them or for distinguishing them from their traditional siblings. Also, little is known about whether green or resilient outcomes are realized (UNEP 2016).

An important corollary to this group of finance offerings are the public-private disaster risk finance vehicles provided by entities like the World Bank with reinsurers (World Bank 2018) and similar disaster reduction or risk finance facilities. They are typically used for relief and recovery after a disaster, and the assurance they provide could open investments in climate adaptation and hazard mitigation finances by taking the costs of disasters off future ledgers (UNISDR 2014).

- **Specialized credit and debt arrangements** and private development partnerships. Credit-debt swaps for environmental amenities or ecosystem services (e.g., “debt-for-nature” or ecological fiscal transfers) that support investment in adaptation outcomes could be explored beyond the current climate mitigation uses.<sup>2</sup> Value capture initiatives that combine public land-use policies with private-sector asset gains may be one way to harness these experiments (World Bank

2018). Yet little is known about the effectiveness of these vehicles, and as with specialized bonds, such arrangements have few standards. Building that evidence could support the expansion of the vehicles.

- **Debt capacity building** (such as the Adaptation Fund's Readiness program). The finance vehicles discussed above share a core challenge: that many of the most vulnerable communities, from cities to whole nations, have little to no capacity to take on global debt or to support complex financial tools (Adaptation Fund 2018).

## The Evidence

We identified 54 recent studies or essays that assess the field of public finance for climate adaptation initiatives. Developing countries, especially the least developed, may not be able to meet their adaptation finance needs through budgetary allocations and should be the focus of grants and affordable loans from multilateral or bilateral funds or development financial institutions. Developed countries, on the other hand, are better poised to increase revenue through taxes and fees from those that benefit from adaptation measures. Both specialized bonds and public-private partnerships (PPPs) appear to be appropriate and effective mechanisms to finance adaptation. However, some countries may need more help from international organizations than others to implement these vehicles so that both issuer and investor (in the case of bonds) and both public and private actors (in the case of PPPs) have opportunities to benefit. Finally, debt swaps and debt capacity building have great potential to support countries that are highly indebted and have a major need for adaptation, such as small island nations and those in sub-Saharan Africa.

### Multilateral, National, and State Direct Investments and Finance Facilities

We identified 18 recent monographs as relevant to this area. Most are grey literature from multilateral institutions assessing climate adaptation finance at the national and multinational levels. Some grey literature and peer-reviewed articles explored financing vehicles at the local level. However, most are in developed countries.

A wide array of financing vehicles exists for climate adaptation, from fees and special local taxes to grants and equity from multinational development banks. In 2015–16, market-rate loans provided mostly by multilateral and national financial institutions were the main instrument used to finance adaptation activities. Vehicles that directly connect beneficiaries (of the climate adaptation initiatives)

with the contributors (those who provide the money) appear to be better suited for developed countries, not only because private actors (such as taxpayers) and/or local jurisdictions have the financial capacity to sustain these costs, but because their revenue collection and administration is more effective.<sup>3</sup> Vehicles that involve a wider “distance” between beneficiaries and contributors, such as grants from multinational organizations, are better-suited for the least developed countries. In the middle of this spectrum is funding from national development banks, which are well-suited for middle- and high-income countries.

This category includes all direct investments from multilateral public funds supported by donor countries’ pledges, public finance administered through development agencies, regional and national funds resourced through international finance, and domestic and local budget allocation. Within each conduit is an array of finance facilities that include grants, loans (either at or below market rate), equity, guarantees, and assessments. At the multilateral level, the literature is mostly grey and focuses on the deployment of capital into developing countries by multilateral or regional funds and development banks. At the national and local level, peer-reviewed journal articles are more prevalent, focusing largely on the tools that national and local governments can use to raise revenues that can later be invested in adaptation.

In 2017 and 2018, the two-year average of total climate finance flows by public and private actors was \$579 billion. Within this, over \$252 billion (44 percent) was deployed by public actors, \$37 billion came from government budgets, \$3 billion from climate funds, and \$212 billion from development finance institutions. The remaining \$326 billion comprised capital from commercial financial institutions, infrastructure funds, institutional investors, corporate actors and households. The most common instrument among all development financial institutions was project-level market-rate debt, followed by low-cost project debt. For government budgets, grants were the most common vehicle. Across all sources, most capital was deployed for mitigation. Of the total \$579 billion, only \$30 billion (5 percent) was used for adaptation (Buchner et al. 2019). Geographically, \$356 billion of the total climate finance flows went to non-OECD countries. East Asia and the Pacific region received most of the capital (46 percent), followed by Africa (13 percent), and Latin America and the Caribbean (12 percent) (Buchner et al. 2019).

Funding sources and channels for climate mitigation and adaptation are growing. Many developed countries, under the principle of “common but differentiated responsibilities,” have pooled resources to support international funds with the aim of addressing climate change. These climate funds range from less than \$10 million to more than \$7 billion, and many have a specific focus within climate mitigation and adaptation. Table 2 describes nine of the most relevant funds.



However, the climate fund landscape has few resources, which are spread thinly across many small funds with overlapping remits (Barnard et al. 2014). Developing countries often face barriers to accessing these funds, including a lack of information and to climate funds through the approved implementing partner (in most cases different from the designated funding agency) and weak policy coordination (Keuck et al. 2019). The evidence suggests that even when funds are accessed, they do not deliver tangible adaptation outcomes in most cases. A study of 60 projects funded by climate funds found that portfolios were largely focused on policy, planning, and capacity-building projects (Kuhl, Van Maanen, and Scypers 2020). To improve effectiveness, climate funds need to become more flexible and less risk-averse, work closer with national stakeholders, and improve measurement and reporting (Barnard et al. 2014). Climate fund use could also benefit from centering adequate and fair distribution of funds and increasing attention to governance, efficiency, and accountability (Khan et al. 2019).

TABLE 2

## International Climate Change Funds

Climate change fund	Objective	Mode of support	Description
Green Climate Fund	Mitigation and adaptation	Grants, concessional loans, and capital contribution	At \$10.3 billion, it is the largest climate change fund.
Adaptation Fund	Adaptation	Grants	Established to finance adaptation projects and programs in developing countries that are party to the Kyoto Protocol and are particularly vulnerable to the adverse effects of climate change. As of 2018, \$426 million was committed to projects.
Least Developed Countries Fund	Adaptation	Grants	As of October 31, 2019, 51 countries (LDCs and former LDCs) had accessed a total of \$1.4 billion for the preparation and implementation of national adaptation programs.
Special Climate Change Fund	Adaptation and transfer of technologies	Grants	Operated by the Global Environment Facility, with the World Bank as trustee, to support adaptation and technology transfer projects.
Africa Climate Change Fund	Mitigation and adaptation	Grants	Established by the African Development Bank Group. Total contributions to the fund since its inception in 2014 are about \$13.8 million.
Global Climate Change Alliance	Mitigation and adaptation	Grants and technical assistance	Members are health- and development-focused organizations from around the world. Supports developing countries in adapting to and mitigating climate change.
International Climate Initiative	Adaptation, mitigation, biodiversity conservation, and related activities	Grants	Finances climate projects in developing and newly industrialized countries, as well as countries in transition economies. Aids mainly through technology cooperation, policy advice, and capacity development.
Nordic Development Fund/Nordic Climate Facility	Climate change (mitigation and adaptation) and poverty reduction	Grants	The fund is the joint development finance institution of Denmark, Finland, Iceland, Norway, and Sweden. It provides co-financing for climate change and development activities in low-income countries, with an emphasis on sub-Saharan Africa.
Clean Technology Fund	Transfer of technologies	Concessional finance	Seeks to achieve “transformational change” in developing countries toward low carbon development strategies through public and private sector investments, harnessing the implementation capacity of the World Bank and regional development banks.

**Sources:** Hailey Keuck, Owen Scott, Sophia Dahodwala, and Christopher Perine, *Financing the Climate-Health Nexus* (Washington, DC: US Agency for International Development, 2019); Smita Nakhooda, “Understanding the Effectiveness of International Climate Funds: Synthesis Note” (London, GBR: Overseas Development Institute, 2014).

In 2017 and 2018, multilateral development banks (MDBs) mobilized an average of \$57 billion annually for climate change efforts. These institutions support countries to improve their policy and institutional foundations to leverage finance (Bhattacharya et al. 2018). MDBs' climate finance hit a historic high in 2018, growing 22 percent from 2017, largely driven by the World Bank, whose commitments grew 61 percent. The growth was even more dramatic for adaptation finance, which increased by 75 percent compared with 2017. Climate finance as a share of all MDB operations also reached an all-time high in 2018, at 29 percent (World Bank 2018).

The positive trend was expected to continue, at least before the current pandemic. In its Action Plan 2018, the World Bank commits to boost overall finance for adaptation through “its own lending, by crowding-in private sector finance, and by facilitating, where feasible, access to and effective use of additional concessional finance.” It says it will increase its direct adaptation climate finance to \$50 billion in the 2021–25 fiscal period (more than double the 2015–18 level) and put adaptation and resilience on an equal footing with mitigation (World Bank 2018).

These positive MDB trends reveal a growing consensus on the need to increase finance for climate-related projects. However, the finance levels are still well below what is needed, and according to experts, no MDB member is fully aligned with the Paris Agreement's goals (Clark et al. 2019). To improve MDBs' effectiveness in driving climate finance, Prizzon and coauthors (2017) recommend that MDBs boost the provision of global public goods,<sup>4</sup> better distribute responsibilities among MDBs, reform their approach to operating in fragile contexts, and expand their lending while moving “from a graduation to gradation approach,” especially for middle-income countries with a combination of measures of balance sheet optimization and general capital increases.

The International Development Finance Club (IDFC) is a partnership of 26 regional and national development banks, financial institutions that provide risk capital for economic development projects on noncommercial bases at the national level.<sup>5</sup> In 2018, member institutions made green finance commitments of \$134 billion, starkly less than the \$208 billion committed in 2017 (IDFC 2019). The drop is in part due to cyclical macroeconomic policy evolutions in some countries that affected development banks' overall financial commitments and therefore green finance levels. Most NDB green commitments in 2018 went toward green energy (85 percent of all climate finance), while only 12 percent, or roughly \$15 billion, went to adaptation. Commitments to adaptation projects among IDFC member banks almost tripled between 2015 and 2018 (IDFC 2019).

Challenges and opportunities for national development banks vary by region. The European Environment Agency reports that adaptation work often is done via projects in individual agencies such

as water management, transport, and nature conservation. This approach makes integrating comprehensive adaptation strategies difficult, which also lowers the chances that a given project will obtain funding (EEA 2017). In Asia, none of the six largest national development banks reports full alignment with the Paris Agreement, which provides opportunities for the future (Dunlop et al. 2019). The examples of Brazil and South Africa provide lessons for their respective neighbors about the need for clearer mandates, strategies, and tools for climate action, shifting from financier to mobilizer of investment for infrastructure, and ensuring support from governments and the international climate finance community. To transition to mobilizers of other sources of finance, development banks must “(1) carry risks not readily assumed by the private sector; (2) improve the risk-return profile of infrastructure investment to mobilize commercial capital; and (3) catalyze markets through a programmatic approach of taking nascent climate solutions to market and demonstrating project viability” (Morgado et al. 2019, 7–8).

National and state governments can also use their budgets to fund climate adaptation projects. Their ability to do so depends on their revenue collection capacity through taxes, fees, or other mechanisms (Davis and MacLean 2019). National and local governments have myriad tools to bring in revenues. However, many of the tools are generally more effective in the developed world, where fiscal capacity is higher.<sup>6</sup> State governments in the United States, for example, can leverage tools like special assessment districts (which finance public projects by distributing debt repayment across the property owners receiving special benefits from the project); business improvement districts (which levy an assessment against businesses or property to fund services or improvements that benefit the assessed businesses or property); ad valorem property taxes; property tax increments (which capture the increase in assessed property value within a defined district for the purpose of repaying debt used for improvements within the district); general taxes; and gas taxes (AECOM 2018; Keenan 2019). Furthermore, taxes could be delineated to account for unequal benefits of local public goods across taxpayers—for example, imposing higher property taxes on oceanfront properties (Mullin, Smith, and McNamara 2019). Local governments could also securitize statutorily unallocated revenue under a cap-and-trade program<sup>7</sup> to lever an investment trust fund for climate adaptation (Keenan and Gumber 2019). Finally, governments can collect fees from those who benefit from an adaptation project or measure, such as a storm water utility, although this type of fee may not provide sufficient revenue to fully fund this type of infrastructure (Riggs and Kirk 2019).

## Specialized Bonds (Green, Resilience, Climate)

Bonds are debt securities that promise to make payments periodically for a specified period. If the issuer is using the debt to finance “pro-environmental” initiatives, the bonds are considered climate or green bonds (Wisniewski and Zielinski 2019). Within this group are even more specialized bonds, such as catastrophe—or resiliency—bonds. Sixteen recent monographs were identified as relevant to this area, divided almost equally between peer-reviewed journals and self-published reports from international organizations and think tanks. In general, the literature agrees that green bonds are an appropriate and effective way to finance climate adaptation and mitigation projects, with ample potential for scaling up. However, some cautionary lessons and areas for improvement can be found among these papers—for example, one author warns that municipal green bonds could be used to fund projects that perpetuate racial disparities in cities in both the developed and developing world.

Green bonds are typically asset-linked and backed by the issuing entity’s balance sheet, so they usually carry the same credit rating as their issuers’ other debt obligations. On paper, these bonds can appeal to socially or environmentally responsible investors looking to diversify their portfolios with fixed payment securities that deliver some social good (Tolliver, Ryota-Keeley, and Managi 2019). In this sense, green bonds can supplement and fill gaps in the budgets of local or national governments whose access to capital markets is limited (Clap et al. 2015) while transferring the risk of performance to investors (Vegh 2018).

The Climate Bonds Initiative—an international, investor-focused nonprofit organization—reports that by the second quarter of 2018, 869 public and private entities had issued climate-aligned bonds,<sup>8</sup> with \$1.45 trillion outstanding, 32 percent of which were outstanding green-labeled bond volume. This record-breaking volume is a \$72 billion increase from 2017. Among nations, China tops the rankings, having issued the highest volume of climate-aligned bonds, followed by the United States. As a region, Europe has the highest volume of outstanding climate-aligned bonds, led by France, the United Kingdom, and Germany. India, South Korea, and Russia are also important issuing markets. Transport, with \$532 billion outstanding, is the largest theme in the climate-aligned universe, followed by energy, multisector, and water, respectively (CBI 2018).

An increase in the number of investors looking for socially responsible transactions may not be the only explanation for the growth in the green bonds market since 2013 (CBI 2018). Evidence exists that green bonds have a premium in terms of return (some authors call this “the greenium”). In a sample of 89 bonds in which half were labeled “green,” the green bonds were found to have higher yields and lower variance and to be more liquid (Bachelet, Becchetti, and Manfredonia 2019). Similarly, a panel data

regression looking at the credit spreads of green and regular bonds found that the former were traded at a premium of 63 basis points (Nanayakkara and Colombage 2019). A recent study of 121 European green bonds issued between 2013 and 2017 found that green bonds had higher convenience yields<sup>9</sup> than those that were not green, with the advantage more pronounced for corporate issuers than for institutional ones (Gianfrate and Peri 2019). The premium also applies to municipal bonds. A study of indexed municipal green bonds in the United States found that they outperform the closest equivalent Standard & Poor's index. The study also found a statistically significant green premium in the secondary market of green municipal bonds (Tolliver, Ryota Keeley, and Managi 2019).

Despite the ample evidence that expanding the use of green bonds could be beneficial, the field has significant areas for improvement. The Climate Bonds Standard and Certification Scheme was established in 2015 to provide guidance to issuers and assurance to investors in a voluntary market. However, to date, only 15 percent of all green bonds issued globally (by value) have been certified under this mechanism (CBI 2019). Lessons from New York City and Cape Town, South Africa, raise questions about using municipal green funds for adaptation; their use and the deployment of capital collected through this mechanism may intensify inequalities, both financial and environmental, by increasing risks for the poor or working-class people of color (Bigger and Millington 2020). The authors call for increasing national funding for municipal adaptation instead, to have more capacity to progressively distribute risks. The literature also recommends improving the post-issuance reporting of green bonds and tracking a wider array of sustainability and climate metrics (Tolliver, Ryota Kelley, and Managi 2019).

## **Specialized Credit and Debt Arrangements and Private Development Partnerships**

Eight recent monographs were identified as relevant to this area; most are gray literature, commissioned or supported by multilateral organizations, such as the World Bank or the United Nations. Compared with private development partnerships, also known as public-private partnerships, the literature is limited in its overview and assessment of specialized credits and debt arrangements. Export credit schemes—agencies that support national exporters competing for overseas sales, either in the form of direct credits to foreign buyers or by providing a guarantee or insurance for the benefit of lenders financing the export<sup>10</sup>—are the most common form of specialized credit arrangements for climate-related purposes found in the literature. These schemes have been assessed and found to be effective ways to retrofit ships and related infrastructure to be more environmentally sustainable (Schinas et al. 2018; Chuah 2020). However, if these schemes are mostly focused on reducing carbon

dioxide emissions in international trade, to what degree they can contribute to climate adaptation is unknown.

Debt swaps are the most common instrument in the literature's overviews of special debt arrangements. Debt-for-nature swaps are financial transactions in which a portion of a developing nation's foreign debt is forgiven in exchange for local investments in environmental protection or climate adaptation measures. This tool builds on a history of debt relief as an efficient modality for poverty reduction spending (Mitchell 2015) and is especially relevant for SIDS, which are some of the most heavily indebted developing countries in the world on a per capita basis and are highly vulnerable to climate change impacts (Fuller et al. 2018). The United Nations Economic Commission for Latin America and the Caribbean agrees with the positive assessment of debt-for-nature swaps and has called for implementing the mechanism via the SIDS Accelerated Modalities of Action Pathway.<sup>11</sup>

Swaps are not without risks, however. Uruguay and Spain undertook a "debt-for-efficiency" swap agreement. But its terms left limited additional fiscal space for Uruguay, and the forgiven debt was too small to create indirect benefits. This arrangement also bound Uruguay to purchase goods and services solely from Spanish companies (Cassimon, Prowse and Essers 2014).

PPPs are "a long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance."<sup>12</sup> As a tool for climate change mitigation and adaptation, PPPs may lead to better outcomes on carbon dioxide emissions and vulnerability reduction compared with public subsidies whenever a fair distribution of bargaining power exists between the private and the public actors (Buso and Stenger 2018). Furthermore, PPPs could bring more private investment to adaptation infrastructure for municipalities in developing countries, which usually lack the robust institutional, fiscal, and regulatory systems necessary to attract those investments (White and Wahba 2019). One way that municipalities can use the PPP model for climate adaptation infrastructure is through the Public Asset Corporation—a publicly owned, privately managed institution that leverages public assets through land value capture (Noring 2019).

PPP examples are more prominent in urban areas than rural ones, whose residents may be more distrustful of private actors. However, PPPs appear to be effective mechanisms for financing adaptation projects in rural settings. A study in southwestern China found that public entities were limited in supporting farmers adapt to droughts, but farmers distrusted the engagement of private enterprises. In this context, PPPs proved to be a reliable mechanism to "mobilize funds from multiple sources, share

costs, risks and benefits among different stakeholders, combine both scientific and local knowledge, and reduce uncertainty through formal and informal institutions” (Zhang et al. 2018, p. 138).

The Public-Private Infrastructure Advisory Facility has brought attention to areas in which PPPs could improve as tools in the fight against climate change. For one, climate resilience is still not being sufficiently considered in PPP policy frameworks for infrastructure. Additional recommendations are to find partnerships with the insurance industry at a strategic level; to assess potential risks by making better use of information technology and satellite imaging to collect and analyze climate data; to use PPPs in combination with global climate finance sources; and to take a multisector, systems-wide approach to developing climate-smart infrastructure (Sundararajan and Suriyagoda 2020).

One approach to improving the use of PPPs for climate adaptation and other purposes is the guiding principle of “People-First PPPs,” proposed by the United Nations Economic Commission for Europe. It refers to PPP contracts whose core objective is delivering value for people. (UNECE 2018).

## **Debt Capacity Building**

Nine recent monographs were identified as relevant to this area; they are roughly equal parts grey literature and peer-reviewed journals. The capacity-building literature is heavily focused in Latin America, with some monographs on Africa. The latter region appears to have the greatest need for debt capacity building. The literature also focuses mostly on debt swaps, for climate adaptation or other purposes. And even though debt swaps consistently appear as an adequate way to increase debt capacity, some authors call for more regulation and transparency in the market.

Developing countries can receive help building their capacity to address indebtedness within their long-term development policy frameworks through technical assistance, which can take many forms. The literature assessing this type of intervention for financing climate adaptation is limited. The monographs that we identified provide an overview of existing efforts and lessons learned from past experiences. Two such experiences are the International Monetary Fund and World Bank’s Medium-Term Debt Management Strategy framework with its associated capacity-building efforts and the United Nations Conference on Trade and Development’s “capacity-building for debt sustainability in developing countries” project, which focuses on Asia, Africa, and Latin America.

So far, the Medium-Term Debt Management Strategy has received positive feedback from national authorities who received technical assistance. Also, various quantitative indicators suggest that the program was beneficial and that the benefits were generally sustained (WB and IMF 2017). The need



for this type of assistance is particularly high in sub-Saharan Africa, which has faced increased indebtedness since the 2008 financial crisis. In the region, the share of concessional public debt has been declining while that owed to private creditors and non-Paris Club bilateral creditors has been rising. In this context, capacity building could be more effective if used to gradually move from debt management to balance-sheet management of the public sector, as well as policies to boost the efficiency of public investment (Calderón and Zeufack 2020).

Some debt capacity building focuses on fiscal capacity. Enhancing revenue collection can help a national or local government pay existing debt and take on more. However, experiences like those of Mexico, which used property and land-based taxes to increase the country's capacity to repay municipal bonds, are cautionary. According to the evidence, this approach was ineffective, mainly because Mexico's institutional and legal framework creates an artificial environment of fiscal solvency (Espinosa and Martell 2015).

Other debt capacity building initiatives tackle debt restructuring. These initiatives should consider that market-based systems for restructuring may not ensure efficient and fair solutions to sovereign debt crises. The contractual approach for restructuring should be complemented by a multinational legal framework that facilitates restructurings based on principles of efficiency and equity (Guzman and Stiglitz 2016).

## The Opportunity

Resilience, especially hazard mitigation and adaptation to climate change, can still become an attractive investment opportunity. It is a matter of finding ways to quantify and present its benefits, or what the Global Commission on Adaptation calls “the triple dividend.” The first dividend refers to avoided losses. Early warning systems, for example, are considered to save lives and assets worth at least ten times their cost, and while making infrastructure more climate-resilient is known to add about 3 percent to the up-front cost of the project, it has benefit-cost ratios of about 4:1. The second dividend is the economic benefits of climate adaptation projects—or example, by enabling investments that would otherwise be too vulnerable to climate risks. Finally, there are social and environmental benefits, such as mangrove preservation and restoration, which can lead to benefits of up to 10 times the costs, particularly from the mitigation of losses due to natural disasters.<sup>13</sup> Overall, the research suggests that investing \$1.8 trillion from 2020 to 2030 on early warning systems, climate-resilient infrastructure, improved dryland agriculture crop production, global mangrove protection, and more resilient water resources could generate \$7.1 trillion in total net benefits (Global Commission on Adaptation 2019).

In this sense, and considering core challenge to adaptation finance, the opportunity lies on monetizing the future dividends of adaptation to incentivize action today. Among the four main categories of public finance vehicles that were identified to tackle the challenges of resilience and capitalize the opportunities of investing in adaptation, however, the opportunities of interventions without having extensive capital or political authority are limited. Only a sizable contribution—at a minimum of tens of millions of US dollars and likely on the order of hundreds of millions of US dollars—would leverage other investors.

For existing multilateral and national finance facilities, for example, advocates could be resourced to pressure these organizations and their citizens or constituents for additional funding devoted specifically to resilience projects (such as infrastructure meeting the resilience screens defined in the previous action area). This advocacy would need to be place-based, and it could be effective at multiple levels of government. Supporting research and demonstrations of alternative tax or fee schemes for public funding of resilience projects can also be an effective use of resources, such as those conducted by environmental organizations for public water and storm water utility districts in the past decade. Otherwise, contributing funds directly to existing facilities is another, though less innovative option.

Private financing of public projects including bonds also presents a few, though promising, opportunities. Recent examples of these include the International Municipal Investment Fund, the UNCDF Local Climate Adaptive Living Facility, and the Rockefeller Foundation-funded Urban Resilience Fund. Additional funds could be used as levers for incenting private investors (such as funding credit guarantees for a portfolio of investments). Alternately, an independent investor concerned with resilience building could become a pioneer investor in private offerings or an early purchaser of bonds to signal their feasibility to markets. Assessment tools for private equities, real estate investment trusts, and municipal creditworthiness such as those developed by organizations like Four Twenty-Seven could also provide a foundation for other investors. However, the glut of reporting and monitoring programs and vehicles of private climate investment suggests limited opportunity in that activity.

Finally, additional resources are always needed to build the debt capacity of low- and moderate-income national and subnational governments, such as the Adaptation Fund's Climate Finance Readiness Program. There are further opportunities to also build the knowledge capacity of government staff to technically prepare projects for possible investment, such as those services provided by global environmental and engineering organizations. Supporting project preparation and debt capacity for projects in specific resilience categories or vulnerable places could be a unique point of entry.

Experts interviewed agreed that public-sector investment in resilience is critical but must be coupled with engagement of private sector through blended finance, and they noted the role of multilaterals in supporting capacity building and investing in climate adaptation, especially in the Global South. Resilience will require stable long-term streams of funding, rather than one-off investments, meaning a combination of taxes, earmarks, project investment and bonds will be necessary. Experts also acknowledged the role of policy and regulation to improve investment, by creating incentives for resilient solutions.

While there is consensus that investment in resilience at status quo is insufficient, experts recognized there are challenges with identifying, tracking, and estimating investments in resilience and climate adaptation—which means we lack an accurate understanding of the state of public investment. Interviewees also emphasized the information gaps around risk and cost-benefit analysis are a persistent barrier to resilience investment. This will require investment in data collection, constructive modelling, and investment in metrics to figure out what interventions give value for money, with a focus on making these data accessible across country contexts.

There is a plethora of existing and new tools designed to increase public finance for resilience. Experts identified potential of resilience bonds, with early examples in San Francisco and Miami, and green bond arrangements under development for the Latin American and Caribbean region. While there is a clearer path for resilience bonds for infrastructure, this tool has the mechanism to work for investment across sectors, where the quality of the asset is the focus. On the other hand, one interviewee expressed skepticism that sovereign debt swaps, despite high level of current interest and attention, would be scaled and used broadly.

In addition to discrete instruments, efforts to provide risk guarantees, debt financing, or concessional equity for lending will be essential to reduce investment risk and serve as proof of concept for novel adaptation approaches and build capacity for quantifying risk. Experts recognized the role of philanthropy to support research and documentation of these new approaches. Multilaterals were identified as a key actor help broker relationships with private sector and banks for financial instruments for investment in resilience and influencing such entities to consider resilience in their lending. However, experts also acknowledged that the current pandemic will put an unprecedented strain on public capacity to invest in resilience, as well as likely lead to downgrading of bond rating and flight of institutional investors, which will require the field to reconsider public-sector potential for resilience investment in the short to medium term.

Among the thought leaders interviewed for this study, there were clear ideas about moving forward with civil- and public-sector actions that could assist the private-sector finance markets, too. Because commercial entities are either unwilling or unable to undertake such research investments given uncertainty about the returns that will accrue to them, the civil sector could push boundaries by investing in public good research and bear the much needed first loss to “potentially unlock groundbreaking innovations.” These seed investments could be most powerfully felt at the local and municipal levels—such as through community development bank and similar financial institutions—since these units have been less of a focus for private-sector players globally.

## Unit of Intervention

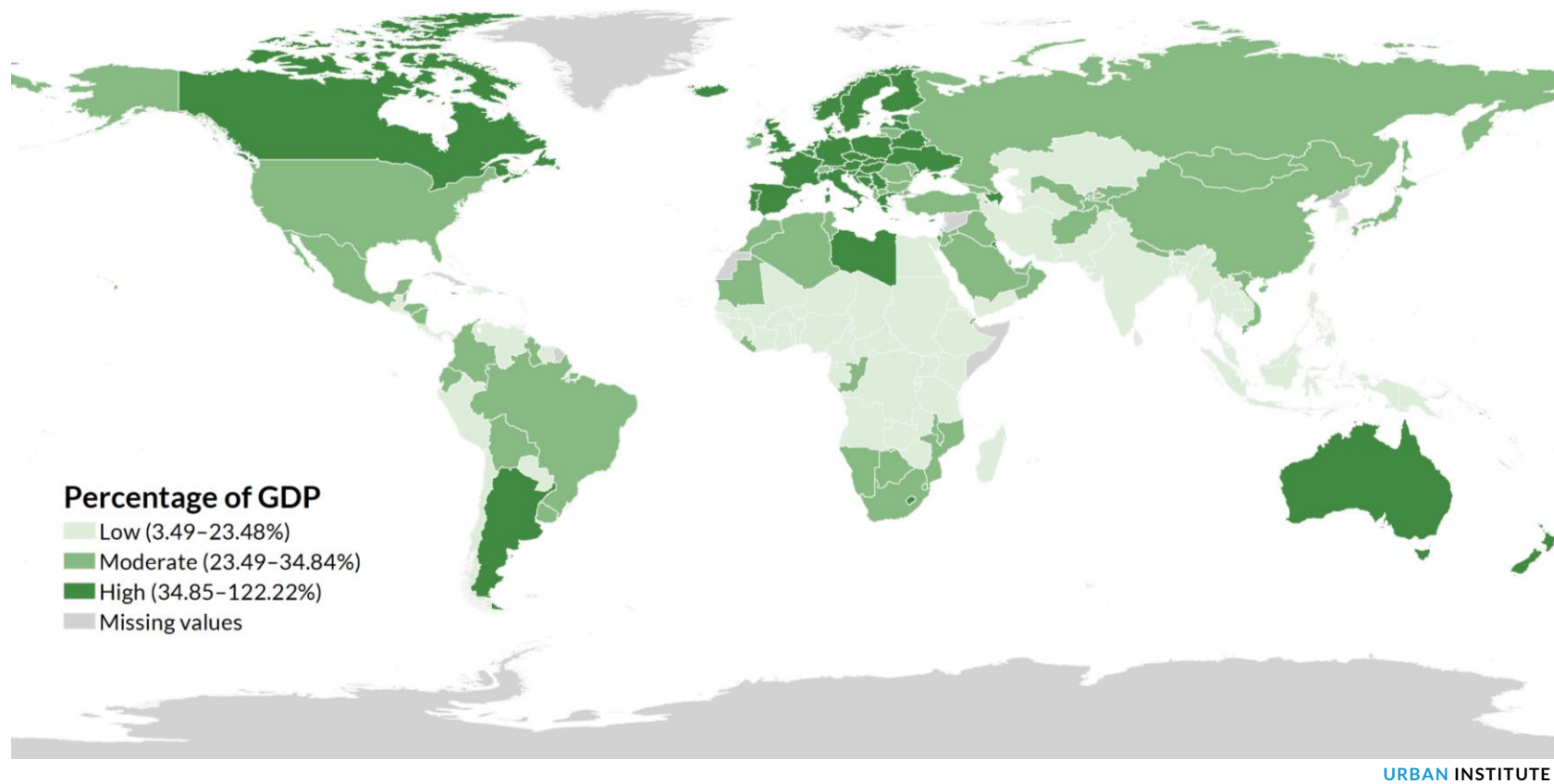
Public finance, and private investments in it, can occur for any scale of governmental level (national and subnational), though transactions occur typically in national markets or through individual brokers or asset managers. Similarly, debt capacity and project preparation facilities benefit any level.

## Scale of Intervention

Investment strategies are best scaled in contexts for which there is minimal financial and project risk, typically higher-capacity jurisdictions in upper-income nations. Nations with high proportions of public revenue in relation to gross domestic product (figure 14) are especially well-suited to innovations in bond and related public finances, while those with high proportions of public debt (figure 15) may be sites for specialized private investments and PPPs. Other strategies, such as capacity-building efforts, are best suited for other economic conditions—such as nations with low or now credit standing (figure 16)—though piloting financing innovations in middle-income nations’ subnational governments could prove the concept for scaling to other places.

FIGURE 14

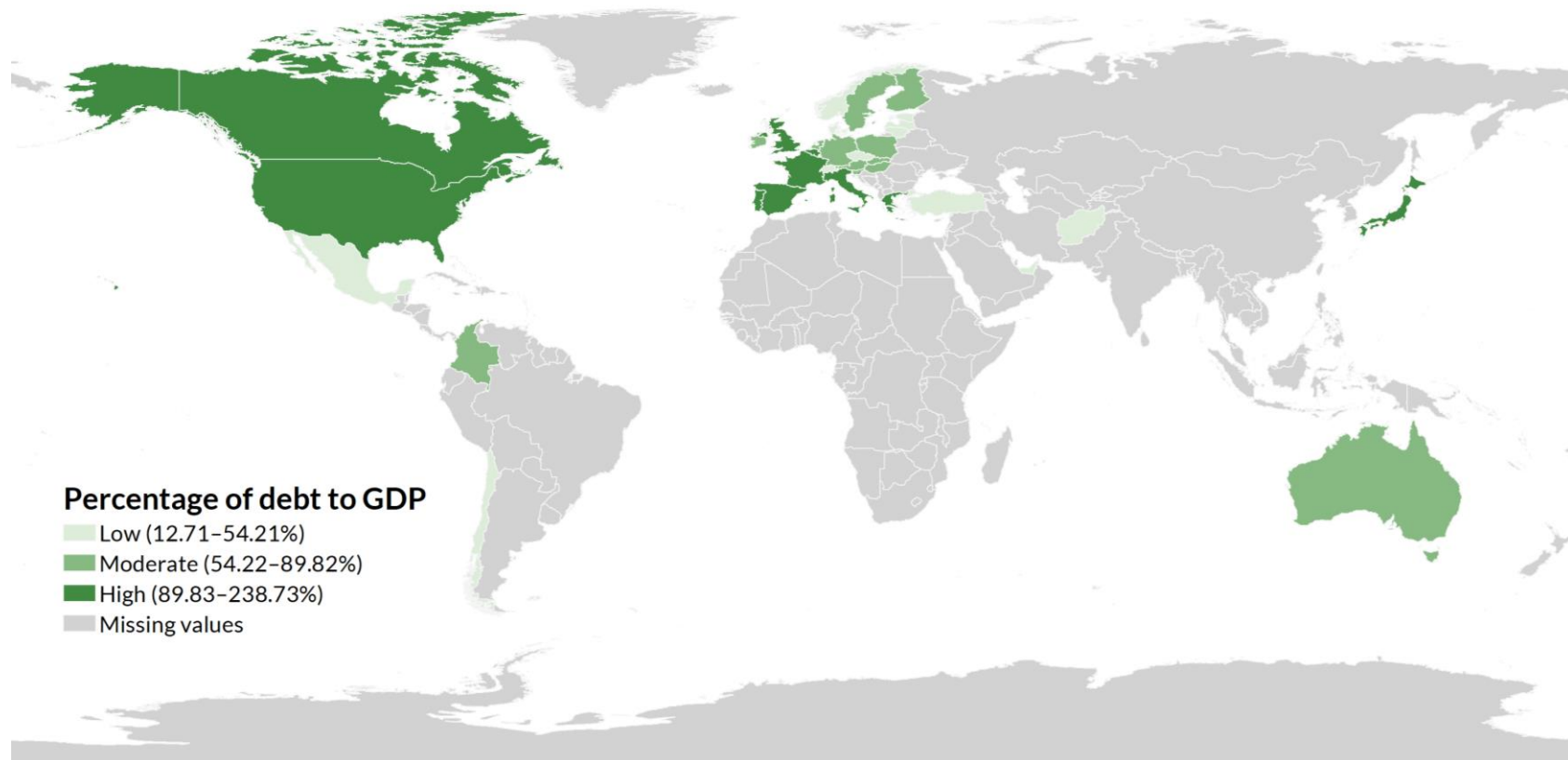
Public Revenue as Percentage of National GDP, 2017



Source: “Total Revenue in Percent of GDP,” International Monetary Fund, accessed April 1, 2020, <https://data.imf.org/?sk=77413F1D-1525-450A-A23A-47AEED40FE78>.

FIGURE 15

Public Debt as Percentage of National GDP, 2018

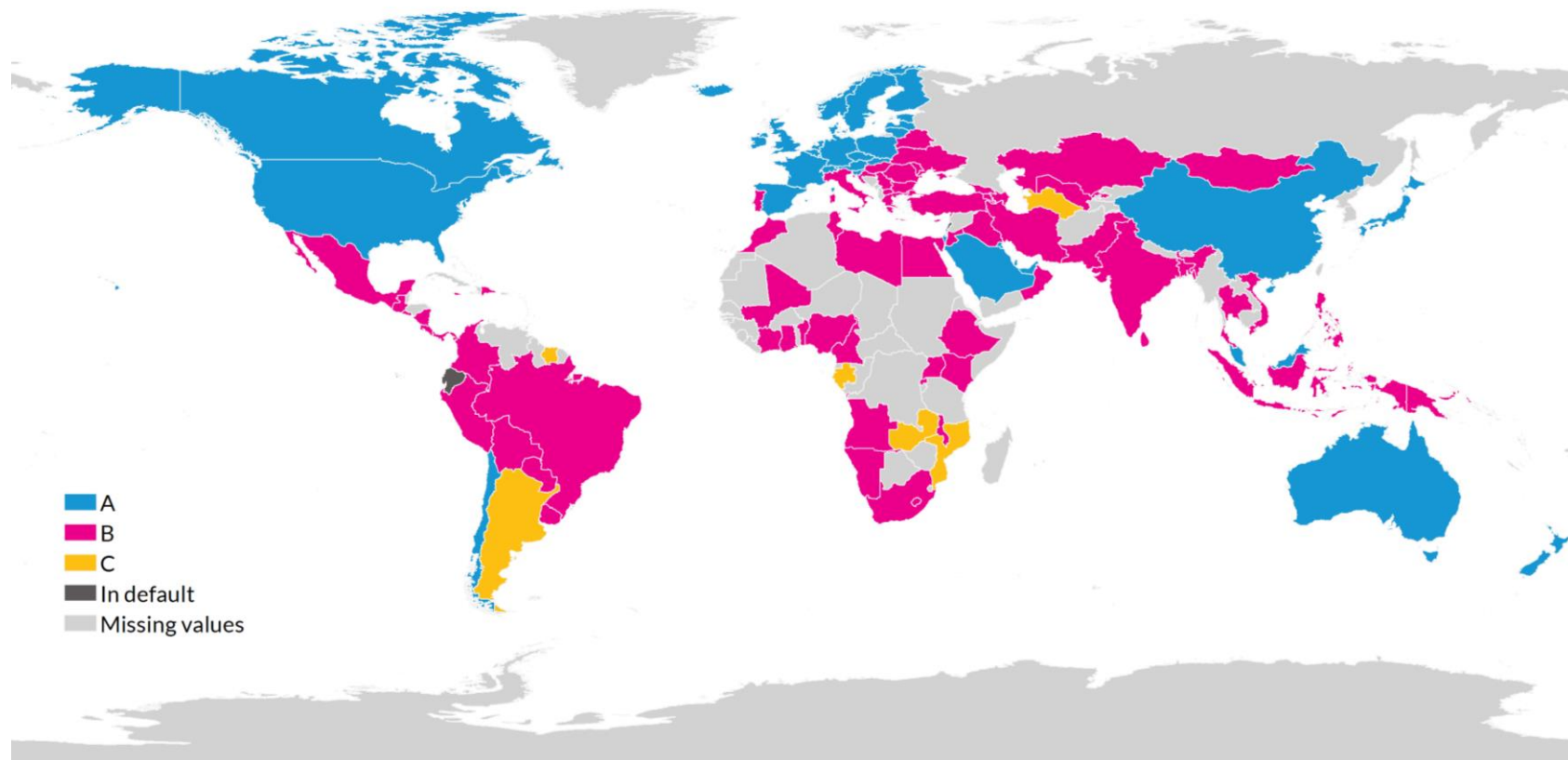


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Source: “General Government Debt,” OECD Data, accessed April 1, 2020, <https://data.oecd.org/gga/general-government-debt.htm>.

FIGURE 16

Sovereign Credit Rating, 2020



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Source: "Fitch: Sovereign Ratings List," Countryeconomy.com, accessed April 1, 2020, <https://countryeconomy.com/ratings/fitch>.

## Summary

The four categories defined in this action area are a global work in progress. However, the ability to pay for so many of the other resilience action areas in this assessment poses a fundamental need in all financial contexts, whether wealthy or developing. Even in high-income nations, there is a wide variety of capacities to fund resilience efforts, to harness finance or take on debt for them, and to articulate projects that can qualify for financial support while still technically providing social and environmental benefits. The need for more money dedicated to resilience is clear and massive. There is much room for growth in this space.

However, the points of entry are narrow and require highly specialized financial skills and, often, sizable resources even for the most accessible pilot opportunities. Further, the chain of outcomes from supporting financial facilities, vehicles, or other tools, through the project being funded (such as infrastructure), to the resulting individuals and communities is long and the ability to predict the number of beneficiaries is complicated. Despite these limitations, there are still many potential partnerships and strategies to explore.

- Assisting with investor assessment tools for resilience investments, public and private and at all scale of potentially funded projects, could be a feasible entry point. Providing resources for investor assessments of hard-to-assess opportunities—such as those for untested infrastructure types like ecosystem defenses, or for lower-capacity, revenue-limited jurisdictions' projects—could also be a distinctive contribution.
- Publicizing and directly investing in pilot investment opportunities could send market signals that would leverage a wider pool of investors.
- Providing other resources and tools to build the financing and technical capacity of low-resourced jurisdictions to ensure that they can access future funding and present feasible projects for that funding could fill a large gap for resilience-needy communities.

As with infrastructure, partnerships with other organizations that are currently making advances in these spaces, such as the Adaptation Fund, or the climate finance centers of most large environmental organizations, could ease entry. Transitioning these resources require a long vision, but one that is fundamental to the feasibility and expansion of all other action areas.



# Notes

- <sup>1</sup> United Nations Economic and Social Council, “Amid Effects of Climate Change, High Debt, Least Developed, Landlocked, Small Island Countries Struggle to Meet 2030 Agenda, Speakers Warn Political Forum,” July 17, 2019.
- <sup>2</sup> For examples, see UNDP’s Financing Solutions for the Sustainable Development Goals: <https://www.sdfinance.undp.org/content/sdfinance/en/home/solutions.html>.
- <sup>3</sup> See “How much tax revenue do countries collect today?” in Our World in Data, accessed June 3, 2020.
- <sup>4</sup> The International Task Force on Global Public Goods has defined global public goods as “issues that are broadly conceived as important to the international community, that for the most part cannot or will not be adequately addressed by individual countries acting alone and that are defined through a broad international consensus or a legitimate process of decision-making.” <https://nautilus.org/gps/applied-gps/global-public-goods/what-are-global-public-goods/>
- <sup>5</sup> The IDFC member countries are Italy, France, Croatia, Germany, Turkey, Russia, Morocco, South Africa, India, China, South Korea, Japan, Indonesia, Mexico, Peru, Colombia, Brazil, Chile, Argentina. It also includes the Black Sea Trade and Development Bank, the Banque Ouest Africaine de Développement, the Eastern and Southern African Trade and Development Bank, the Central American Bank for Economic Integration, the Development Bank of Latin America (CAF), the Islamic Corporation for the Development of the Private Sector, and the International Investment Bank.
- <sup>6</sup> Roberto Ricciuti, Antonio Savoia, and Kunal Sen, “Low Tax Collection in Developing Economies Has a More Devastating Impact Than We Thought,” Quartz Africa, March 15, 2019.
- <sup>7</sup> Common term for a government regulatory program designed to limit, or cap, the total level of emissions of certain chemicals, particularly carbon dioxide, as a result of industrial activity. See “How Cap and Trade Works,” Environmental Defense Fund, accessed March 18, 2020.
- <sup>8</sup> Issuers of bonds labeled as “green bonds” or issuers that derive at least 75 percent of revenue from “green” business lines (CBI 2018).
- <sup>9</sup> The benefit that comes from holding a physical good as inventory rather than as a futures contract.
- <sup>10</sup> The Dollar Business Bureau, “Export Credit Scheme—Time to Lend a Helping Hand?” accessed March 18, 2020.
- <sup>11</sup> Catherine Benson Wahlén, “Caribbean Leaders Discuss Debt for Climate Adaptation Swap, Caribbean Resilience Fund,” *SDG Knowledge Hub* (blog), October 10, 2019, <https://sdg.iisd.org/news/caribbean-leaders-discuss-debt-for-climate-adaptation-swap-caribbean-resilience-fund/>.
- <sup>12</sup> World Bank Group, “What Are Public Private Partnerships?” accessed March 18, 2020, <https://ppp.worldbank.org/public-private-partnership/overview/what-are-public-private-partnerships>.
- <sup>13</sup> Agency for Technical Cooperation and Development, “Mangrove conservation for disaster risk reduction,” accessed March 16, 2020.

# Direct Financial Services

Improving the social safety net is an underexplored option for building community resilience. Most financial tools that directly serve households are well-tested; however, despite the massive need and sizable potential, few have been applied as resilience resources (Hallegatte et al. 2017). Promoting this safety net by expanding existing financial tools can also address long-standing social challenges such as gender inequality, household wealth disparities, and hunger (IPCC 2014). “Rainy day” savings, ultimately, also help the sunny days (Hoeppe and Gurenko 2006; Hochrainer et al. 2007; Alderman et al. 2009; Meze-Hausken et al. 2009). And with improvements with methodology, such as cell phones community inter-lending, communities can receive resources that they need when they need them.

## The Challenge

People and communities most vulnerable to climate change impacts typically have the least financial capacity to prepare for, absorb, or recover from the associated challenges. Without substantial income and asset bases, they struggle to manage effects such as the loss of livelihoods, drops in crop yields, and destruction of homes (IPCC 2014). In developing countries, people who live in urban areas and have low incomes, including migrants from rural areas, often settle in flood-prone slums because the high cost of housing makes safe housing inaccessible to them. People and communities with low incomes are also disproportionately exposed to indirect climate impacts, especially increased food prices and food insecurity (IPCC 2014). Social and economic factors such as poverty and gender inequality underpin vulnerability to climate change impacts. Climate change promises to exacerbate existing inequalities, further increasing the exposure of vulnerable communities to climate-related hazards (US Global Change Research Program 2018).

The lack of financial resources can pressure people with low incomes to adopt unsustainable coping mechanisms, such as engaging in low-return activities, taking out high-interest loans, and selling off productive assets (Wood 2011). When climate-induced disaster strikes a region, communities will need resources to rebuild. Often, governments focus on equality rather than equity, and resources are not prioritized for those who need them most. For that reason, direct financial services have emerged to provide the households or individuals who need resources the most the avenues to receive those resources. These services are wide-ranging and include cash transfers, climate savings accounts, financial literacy programs, microfinance, and migrant remittances. To build resilience at the individual

and community levels, connecting the services with the vulnerable populations that need them is of paramount importance.

Several gaps persist for these direct financial services, reflecting inadequacies of social protection policies and the failure of critical financial products to reach marginalized populations. Although social safety nets like cash transfers are in place in many countries, they are nascent, yet to reach scale, and often implemented without sufficient consideration of their role in climate adaptation. Climate savings accounts have occasionally been used to rebuild after emergencies or disasters, but they are not specifically in place to treat climate hazards. Additionally, there is unmet demand for microfinance products, and where those products are available, they may not be tailored to the unique needs of the poor. As some studies have found, rigid repayment schedules could have the unintended consequence of increasing vulnerability by limiting coping mechanisms during livelihood shocks (Morduch and Sharma 2002). Taken together, the literature shows that the direct financial interventions offered to assist low-income groups often are only a “patchwork support network” and are not always focused on long-term stability.

A lot of literature suggests that building individual financial capacity before hazards and other climate effects can improve long-term recovery. Included in this group are the following:

- **“Climate savings” accounts.** Research suggests that community savings accounts—such as Slum Dwellers International, Philippines Homeless People’s Foundation, and the Asian Coalition for Community Action (ACCA)—offer households the flexibility and convenience to respond to emergencies (Archer 2012; d’Cruz and Mudimu 2013; Dodman et al. 2010). Organizations like the ACCA, for example, function as a collective loan system that is partially managed by the community it serves (Archer 2012). Added benefits for supporting these savings structures include the legitimacy ascribed to actual households and grassroots groups in their negotiations with local authorities (Dodman et al. 2010) and the development of skills that help communities better manage their finances overall. These tools have occasionally been used to rebuild after emergencies or disasters but are not specifically in place to treat climate-related hazards. When disaster does strike, the financial structures that have been created are also at physical risk (Carcellar et al. 2011). As such, institutional links that hold savings or other alternatives to supporting communities such as community inter-lending are necessary.
- **Migrant remittances** to climate-prone nations. Another flexible form of direct financial services is remittances and similar forms of monetary or **cash transfers** (UNEP 2016). The literature suggests that cash transfers are a viable option for low-income individuals who migrate to build

the resilience in their places of origin because of financial insecurity or for those involved in rural-based activities (IFAD 2010). In some cases, remittances, while hugely important to low-income households, account for only a small portion of total household income (IFAD 2010). However, remittances can have a substantial impact on resilience and sustainability, especially in the immediate aftermath of a disaster. In the first month after Hurricane Ivan hit Grenada in 2004, citizens relied on goods shipped to them from relatives abroad. And experts found that the value of those goods surpassed the financial support sent to families in the following year (Savage and Harvey 2007).

IFAD (2010) also notes that the mode in which remittances are sent has improved with the technology boom of the 21st century as cell phones and other mobile technology have become more affordable to low-income farmers. For example, M-PESA is a mobile money-sharing service in Kenya that offers savings, domestic money transfers, and other services and is used by roughly 40 percent of the adult population. Remittances may also be used to support community-level adaptation infrastructure when aggregated (UNEP 2016).

- **Financial literacy and counseling services.** Financial literacy and counseling activities could be used with other direct financial services (Carcellar et al. 2011). When disaster strikes, low-income communities and other underrepresented groups are hit the hardest, and declines in credit scores are larger and occur earlier in the most vulnerable communities (Ratcliffe et al. 2019). Financial capacity building before disasters is among the solutions to combat post-shock financial stress. Governments and other sectors could assist in setting up planning or training for climate-related “rainy day” needs and offering financial incentives to households that participate.

These solutions could involve partnerships among traditional multilaterals, development agencies and banks, charitable safety net programs that have been proven mechanisms for delivering financial aid, and banking and related retail financial institutions, which have an interest in not only integrating unbanked or underbanked households but ensuring that those households can maintain credit and debt obligations after shocks.

## The Evidence

Little scholarship or practitioner guidance addresses financial service-provided social safety nets and related financial protections that are specific to resilience, despite the growth in other climate-

responsive social protections. In theory, however, the concept of financial assistance applies to any shock or diminished capacity. Consequently, the literature references financial assistance generally.

## Cash Transfers

Seventeen monographs were identified as relevant to this area. Most are policy analysis and case studies; a few are experimental studies, including the first impact evaluation exploring the effect of cash transfers on climate adaptation. Although the studies generally provide evidence of how cash transfers can help build resilience and reduce vulnerabilities that stem from structural deficits (lack of assets, income, and education), they also comment on the insufficiency of transfers, noting the need for such interventions to be complemented with broader social policies.

The evidence that cash transfers reduce poverty and build individual autonomy is unambiguous. This matters in attacking a structural deficit (lack of income) that shapes adaptation outcomes. Income gains provide the resource base on which people can adapt to climate change, such as undertaking investments that promote livelihood diversification (Zeigler 2016). The available literature points to at least three ways that cash transfers help build resilience to climate impacts. Several studies show that cash transfers have many purposes.

First, they help meet existing needs such as nutrition that are essential for adaptation. Implemented by the national government, Zambia's Child Grant Program for households with children younger than 5 gave female caregivers a cash transfer of about \$12 per month, targeting improvements in income, education, health, food security, and livelihoods. A randomized evaluation of the program showed that it led to a statistically significant increase in total household expenditures (Asfaw 2016). The program also had a slightly higher effect on food expenditure than on nonfood expenditure. In addition, the increase in food expenditures translated into improvements in the quantity and quality of food consumed, thereby boosting food security. After the 2008 droughts in Ethiopia, cash transfers under the Productive Safety Net Program helped households increase calorie consumption by 30 percent compared with households that did not receive cash transfers (Kuriakose et al. 2012).

Meeting basic needs—especially nutrition, education, and health care—is key for adaptation. Adequate nutrition, for instance, is linked to other factors that shape adaptive capacity, especially education, health, and labor outcomes (Adger et al. 2007, as cited in Wood 2011). As a significant body of research has shown, under-nutrition impairs children's physical growth and cognitive development, resulting in productivity losses as well as losses in lifetime earnings. When immediate needs like nutrition are unmet, people and communities are less inclined to pay attention to long-term adaptation

needs (Wood 2011). As experience from a project in Bangladesh demonstrates, building community awareness about climate change is important to promote adaptation, but achieving that goal proved difficult as communities were more concerned about issues of immediate relevance to their well-being (Rahman 2009, as cited in Wood 2011).

Cash transfers could equip poor communities to better respond to climate-induced shocks. They can draw from the extra income to respond to disruptions to their livelihoods and income. Consider Brazil's Bolsa Familia program, which gives households with low incomes monthly cash transfers that range from \$10 to \$23. To receive the benefit, households must meet certain conditions such as documenting their children's school attendance and attending health checkups. One study strongly suggests that the project makes a meaningful difference on the resilience of rural agricultural households because the cash transfers act as a buffer against crop failures and provide flexible income streams that supplement farm income (Lemos et al. 2016). The additional income may also support investments in human capital, which can help reduce future vulnerability (Lemos et al. 2016). Studies in Kenya and Tanzania show a positive relationship between people's ability to draw on extra income and their ability to withstand droughts (Eriksen et al. 2005). Additionally, the previously cited Zambia study (Asfaw 2016) corroborates other results from Zambia which demonstrate that providing households with cash transfers before a shock to agricultural production has strong and positive impacts on food consumption and food security. Specifically, in the face of a shock, extra cash reduces the likelihood of reducing food consumption by 14 percentage points and increases the likelihood of spending savings by 6 percentage points (Lawlor et al. 2017).

Finally, cash transfers are proven to reduce pressure to engage in harmful coping practices. Research shows that a lack of financial resources can push low-income households to adopt harmful coping mechanisms that undermine their ability to adapt to climate impacts. For one, they are likely to consume less or lower-quality food because they are experiencing a shock (Zeigler 2016). A 2017 field study in Zimbabwe uncovered reports that people in drought-affected communities were eating wild foods, which led to the deaths of children (Bailey et al. 2017). Against the background of social relations that drive vulnerability, this study also revealed reports that women were engaging in transactional sex to secure food for their families. Cash transfers from a donor-funded emergency relief program were reported to have "helped or resolved" such issues by giving households means to meet food needs (Bailey et al. 2017). Climate impacts also force households to sell assets for less than they are worth and to withdraw their children from school (Bailey et al. 2017; Mesquita and Burszytn 2016).

Despite their positive effects, cash transfers are criticized as having little or no bearing on the structural issues that constrain adaptation, such as inadequate infrastructure and poor building quality.

Without tackling such issues, cash transfers, at best, improve people's ability to cope *within* less-than-ideal institutional contexts, which calls into question the long-term value of the intervention (Wood 2011), especially because the institutional context for adaptation can undermine adaptive capacity (Eakin et al. 2014). Although cash transfers are effective in improving the well-being of the poor, this does not often lead to increased inclusion in policy or political decisionmaking processes that affect adaptation (e.g., decisions on community infrastructure projects). These critiques are valid but overstated, as they relate to outcomes that cash transfers are not designed to influence directly. However, cash transfers may have adverse consequences—for instance, by exacerbating existing inequality or creating tensions between households that receive cash transfers and those that do not (CARE Programmes 2017). Further study of this is needed.

Cash transfers remain a powerful instrument for improving outcomes of interest, including poverty reduction and adaptation. But they are not a silver bullet and must be accompanied by policy measures better suited to addressing structural challenges. Identifying the appropriate entry points is key for future donor action in this area because cash transfers are typically under national government control.

## Savings Accounts

Seven studies, including case studies and policy analyses, were identified as relevant to this area. Focusing mainly on the community level, a few articles explore how some interventions have leveraged the asset-building quality of community savings to temper the effect of climate-induced shocks and stresses on people. Others explore how savings boost risk preparedness and serve as a “self-insurance” tool. Savings products come in various forms, including traditional and climate-specific accounts and social instruments like savings groups and community savings funds.

The conceptual link between savings and resilience is sound, and available evidence points to its positive contributions to adaptation. However, questions remain on how best to design and deliver such products. Savings may have identical causal pathways with cash transfers: extra cash in the form of savings is expected to provide financial flexibility needed to adapt to shocks. Like cash transfers, savings—in whatever form they take—boost food security and provide an asset base in times of crisis. In northern Kenya, where poverty rates are as high as 70 percent, the BOMA project supported women's savings groups, and women were encouraged to save KES 400 (about \$4) per month. One study found that after six months, savings accumulated through the project allowed women to “build resilience to climate and economic shocks” (Tiwari et al. 2019).<sup>1</sup> The study also reported increased food security for women and their children and increased decisionmaking power for women in households.<sup>2</sup> Also in

Kenya, a randomized experiment found that women offered a mobile savings account earmarked for emergency and personal savings were less likely to engage in transactional sex as a coping mechanism (Jones and Gong 2019). Corroborating these findings are results from an experimental evaluation of the Savings for Change program in Mali which showed that the program positively affected food security; food insecurity was significantly lower in participating villages than in the control group. Although food consumption fell for all households (i.e., Savings for Change participants and nonparticipants) during lean seasons, the study shows that the decline was much smaller for households participating in the program, pointing to the shock-absorbing role that savings can play (Beaman et al. 2014). Unlike the Kenya study, however, the Mali study found that Savings for Change had no impact on women's decisionmaking power.

The adaptation potential of savings extends beyond individual-level impacts. Research suggests that community savings accounts—such as Slum Dwellers International, Philippines Homeless People's Foundation, and ACCA—offer households the flexibility and convenience to respond to emergencies (Archer 2012; d'Cruz and Mudimu 2013; Dodman et al 2010). For example, organizations like ACCA—which is active in Cambodia, the Philippines, and Sri Lanka—function as a collective loan system that is partially managed by the community it serves (Archer 2012). ACCA enables urban, poor communities that are excluded from formal sources of finance to build their own funding systems (Archer 2012). Through such interventions, residents can pool their savings to do small infrastructure projects and assist others with funds to cope with disasters (Archer 2012). Savings tools can also be used to rebuild after disasters (Carcellar et al 2011). Other benefits of community savings accounts are the legitimacy that comes to households and grassroots groups when negotiating with local authorities and the development and demonstration of skills that will help communities better manage their finances overall (Dodman et al. 2010). To illustrate, case studies on savings schemes in Bolivia, India, Uganda, South Africa, and Zimbabwe suggest that savings groups strengthen the political voice, influence, and visibility of the urban poor, especially women. This does two things for resilience. First, it allows the urban poor to build political relationships at the city level, which gives them avenues to contribute to policy discussions on matters that affect communities' ability to adapt, such as housing (d'Cruz and Mudimu 2013). Second, strengthened political voice, combined with a proven savings record, builds communities' capacity to leverage larger amounts of capital for community infrastructure upgrades (d'Cruz and Mudimu 2013).

Although savings groups are known to help people save, the link between savings and resilience is not definitive. More evidence is needed to understand the degree and mechanisms by which savings affect resilience in the face of shocks arising from climate-related events. Additionally, other



evaluations have shown less positive results, noting that low usage of formal savings accounts. Possible explanations for low uptake of such products include limited trust in financial institutions, low proximity to bank branches, and fee structures (Moore et al. 2019). Some people may decide to hold savings outside of formal systems due to social power dynamics. To protect their resources, women—who often have low bargaining power in households—may also “prefer features that restrict access to and reduce liquidity of savings” (Moore et al. 2019).

Despite these gaps, studies that we reviewed suggest that individuals and communities can build resilience by increasing their savings. This reveals an opportunity to promote savings through the introduction or scaling of products that meet the needs of the poor, accounting for gender-differentiated needs. Wrap around services like financial literacy are also needed to improve take-up of those tools.

Looking ahead, institutional links that hold savings or other alternatives to supporting communities such as community inter-lending are necessary, and technology can play a role. Cell phones and other mobile technology have become more affordable to low-income farmers and urban populations. This creates an opportunity for savings products to take on new designs that not only expand access but help people build savings habits (Moore et al. 2019). Jurisdictions where mobile money is widespread are likely to be fertile ground for integrating adaptation goals with other financial services provided through mobile platforms. In Kenya, for example, the mobile money-sharing service known as M-PESA offers savings and domestic money transfers and is used by roughly 40 percent of the adult population (IFAD 2010). Finally, the available literature strongly indicates that realizing the community-wide benefits of savings requires strong local organizations that can inspire, lead, and sustain collective action to build resilience.

## **Microfinance**

Microfinance is the provision of financial products, including loans, to low-income populations or marginalized groups that lack access to financial systems or institutions. We identified 10 studies that discuss microfinance products or services in the context of climate change adaptation. With a few exceptions, the analyses of the links between the two are of weak or middling rigor. Several studies examine the resilience-building potential of microfinance, specifically through its impact on poverty. However, one study presents causal evidence—from six randomized trials—showing that microcredit impacts are modestly positive, but far from transformative.

Most studies examining the link between microfinance and adaptation have been exploratory, documenting its promise but ultimately providing limited evidence of its effectiveness in improving adaptation. Put differently, the literature includes several arguably sound theoretical claims that have little or weak empirical support. Hamill and coauthors (2008) published the first known piece analyzing the role of microfinance in climate change adaptation. The study concluded that microfinance services could enhance adaptation by providing individuals and households with the resources they need to cope with or be less susceptible to climate impacts. What underpins this claim is the simple logic that the more assets people have, the less vulnerable they are. As shown in table 3, the researchers argue that microfinance could have direct or indirect effects on several economic (financial) and noneconomic (social, natural, human, and physical) assets that influence adaptation outcomes. According to the study, a causal pathway might exist between microfinance and adaptation through its impact on asset accumulation and diversification of livelihoods, which, taken together, empower individuals and households to take actions to reduce their vulnerabilities (Hammill et al. 2008).

**TABLE 3**  
**Microfinance Contributions to Livelihood Assets**

	<b>Direct contribution of microfinance</b>	<b>Less direct contribution of microfinance</b>
Financial	<ul style="list-style-type: none"> <li>■ Cash/capital for investing in livelihood activities</li> <li>■ Savings (depending on credit scheme)</li> <li>■ Increase in household assets</li> <li>■ Diversification of assets</li> </ul>	<ul style="list-style-type: none"> <li>■ More regular inflows of money</li> <li>■ Financial safety nets</li> <li>■ Credit standing for future loans</li> <li>■ Improved skills/capacities in financial management</li> </ul>
Social	<ul style="list-style-type: none"> <li>■ Establishment or strengthening of social networks</li> <li>■ Establishment or strengthening of formalized groups</li> </ul>	<ul style="list-style-type: none"> <li>■ Reinforced relationships of trust, reciprocity, and exchange (i.e., through loan groups)</li> <li>■ Informal safety nets</li> <li>■ Increased access to civic or political bodies</li> <li>■ Increased social prestige and value</li> <li>■ Women's empowerment, increased self-confidence</li> </ul>
Natural	<ul style="list-style-type: none"> <li>■ Practice of sustainable soil and water management techniques as a loan condition</li> </ul>	<ul style="list-style-type: none"> <li>■ Capital for investing in sustainable natural resource management practices</li> <li>■ Reduced pressure on natural resource base (as activities are improved or diversified)</li> <li>■ Political empowerment to secure resource rights, land tenure</li> </ul>
Human	<ul style="list-style-type: none"> <li>■ Loans for education, health care</li> <li>■ Skills training, education</li> </ul>	<ul style="list-style-type: none"> <li>■ Increased literacy, knowledge base</li> <li>■ Better health</li> <li>■ Increased employability</li> </ul>
Physical	<ul style="list-style-type: none"> <li>■ Loans for equipment, infrastructure</li> <li>■ Housing, sanitation improvements (as part of credit package)</li> </ul>	<ul style="list-style-type: none"> <li>■ Better health and living environment</li> <li>■ Better infrastructure or equipment</li> </ul>

**Source:** Anne Hammill, Richard Matthew, and Elissa McCarter, "Microfinance and Climate Change Adaptation," *IDS Bulletin* 39, no. 4 (September 2008).

A meta-analysis of randomized evaluations of microfinance described its effects as “modestly positive, but not transformative,” so support for its potential impact is weak (Banerjee et al. 2015). The evaluations were of microfinance programs in rural and urban areas of six countries: Bosnia, Ethiopia, India, Mexico, Morocco, and Mongolia. None of the six studies found a statistically significant increase in total household income attributable to microfinance, nor did they find a statistically significant increase in total consumption expenditure (a proxy for living standards). Findings on the effects of microfinance on food consumption were mixed; four of the six studies found no effect, while the Mongolia study showed a modest increase in food consumption and the Ethiopia study found a substantial decrease (Banerjee et al. 2015). Results were also mixed on whether microfinance increases households’ stocks of durable assets. In Mongolia, access to microcredit increased the stock of household durables, but in Bosnia and India, microcredit access decreased such stocks (Banerjee et al. 2015). A possible explanation for the latter finding is that some households may have to sell off their durables to meet their debt service obligations.

These weak results, however, should not turn our attention from the areas of microfinance with potential, especially business ownership, investments, and profits. The meta-analysis provides strong evidence that microfinance helps businesses expand while increasing profits to an extent (Banerjee et al. 2015). The study also found positive effects on female empowerment, specifically female decisionmaking power, at least in Mexico. It is important to note that none of the microfinance products assessed in the meta-analysis were specified for climate adaptation, suggesting that further evidence is needed to reach a conclusive verdict on the promise of the role of microfinance in adaptation.

Since the initial contribution of Hammill and coauthors (2008), other researchers have examined microfinance in the context of climate change adaptation (Calderone et al. 2019; Chirambo 2016; Dowla 2018; Morduch and Sharma 2002; Moser and Gonzalez 2014; Ruben et al. 2019; Scheyvens 2015). Taken together, these studies help make the case for microfinance as an adaptation intervention even though they hardly offer new evidence of impacts. At the most basic level, microfinance can increase incomes and savings and can be flexible enough to help households cope with consumption shocks that stem from climate-related events (Morduch and Sharma 2002). For sub-Saharan Africa, where more than 60 percent of the population is employed in agriculture, Chirambo (2016) posits that microfinance products could enhance food security and climate change resilience by increasing individual and community income, which can improve agricultural output and expand opportunities to generate income from nonfarm activities. A case study of Agroamigo, Brazil’s largest rural microcredit program serving smallholder farmers supports this finding but reveals an important caveat. Although microfinance is a lending mechanism that can build financial capacity to cope, those tools *increase*

current and future vulnerability by financing livelihood activities (e.g., agriculture) in sectors vulnerable to climate change (Moser and Gonzalez 2014). This problem is likely to be acute among those for whom increased microcredit access does not translate to livelihood diversification. Other studies considering the role of microfinance in rural settings show that it has mixed effects on farmers' take-up of climate-smart agriculture practices.<sup>3</sup> Across a range of studies, some find that credit access allows farmers to adopt practices that require financial investment (e.g., crop diversification and increased fertilizer use), while others show credit access as having no impact on adoption of climate-smart agriculture practices (Ruben et al. 2019).

Beyond its effects on income, microfinance is also said to help build social assets by creating norms, trust, and networks that can be harnessed to deal with shocks such as floods and droughts (Dowla 2018). However, the contribution of social capital to adaptation may be questionable because “climate change will cause disasters that will affect everyone at the same time” (Dowla 2018). What’s more, at the institutional level, microfinance institutions could indirectly help improve adaptation by advising governments on the design and implementation of adaptation plans (Rippey 2011), specifically emphasizing actions that will protect borrowers’ livelihoods and assets (Dowla 2018). Whether microfinance institutions have avenues to such policy discussions is not clear, however. Responsibility for the interests of individuals and households does not rest solely with governments, though. The literature indicates that microfinance institutions could improve their offerings to ensure that their products help make people more secure. In their current state, microfinance products often have strict repayment schedules, which deny households the financial flexibility to cope with shocks and thereby increase, rather than reduce, vulnerability (Morduch and Sharma 2002; Scheyvens 2015).

Conclusions here are far from definitive, and more empirical work can be done to test the myriad predictions about the pathways by which microfinance can enhance adaptive capacity. How best to reconfigure microfinance services to advance adaptation goals is a question that remains. With several countries lagging on financial inclusion indicators, an opportunity exists to implement the reconfigurations that are needed to maximize adaptation co-benefits of expanding access to finance.<sup>4</sup>

## **Migrant Remittances**

We identified 14 papers—a mix of country case studies and policy analysis of varying rigor—that discuss migrant remittances as a form of adaptation. Taken together, the studies (1) situate remittances in the context of the adaptation financing gap, (2) examine how migrant remittances respond to natural

disasters and the extent to which they improve preparedness for future disasters, and (3) comment on linkages between migrant sending and receiving areas, among other issues.

An evidence-based consensus exists that migrant remittances build the adaptive capacity of receiving households and communities, although evidence of adverse unintended consequences also exists. A study in flood-prone rural areas in the Indian state of Assam found that remittances have a positive association with several determinants of adaptive capacity. Specifically, it showed that remittance-receiving households were more likely to have savings accounts and own an insurance product (Banerjee et al. 2017). Remittance-receiving households were also more likely to own more types of communication devices, such as cable TV, mobile phones, radios, and televisions. Ownership of these devices is thought to come with increased exposure to more and different sources of information, and the dissemination of precautionary information can help reduce vulnerabilities at individual and community levels.

If remittances act as a financial buffer for households, then household income levels should not go down when changes to local weather affect household income streams. Yang and Choi (2005) find this to be true in the Philippines, although the evidence is suggestive.<sup>5</sup> In their study, remittance inflows increased after a weather shock, replacing nearly 100 percent of household income lost because of the shock. Additionally, remittances helped receiving households maintain their pre-shock levels of consumption. A cross-country study that included data from Bangladesh, Burkina Faso, Ethiopia, and Ghana supports the finding that remittances increase in response to weather-related disasters (Mohapatra et al. 2009).<sup>6</sup> Specifically, the study estimates that for every \$1 of disaster costs, remittances increase by 50 cents (Mohapatra et al. 2009), although this dynamic might vary depending on the availability of people's access to other coping mechanisms, such as credit.

Remittance flows are also very conducive for adaptation needs because they may be more easily or quickly restored than other income streams (Harvey 2007). Households can lean on these resources to smooth consumption following a shock. Mohapatra and coauthors (2009) found that in Bangladesh, remittances had a positive, statistically significant impact on per capita household monthly consumption 16 months after a July 1998 flood that caused 2 million metric tons of rice crop losses and food shortages that threatened the livelihoods of millions.<sup>7</sup> In both Burkina Faso and Ghana, remittance-receiving households were more likely to live in concrete houses that are disaster-resilient than were non-receiving households, who lived in vulnerable mud-houses at higher rates. Mohapatra and coauthors also show that for Ethiopian households, receiving remittances is associated with lower levels of vulnerability to food shocks, and such households typically do not resort to harmful coping mechanisms such as selling household assets or livestock. Overall, the latter findings point to the

positive effects of remittances on households' disaster preparedness, which are more salient among households that have experienced a disaster in the past (Tapsoba 2017).

Migration itself is a legitimate form of adaptation—people can remove themselves from environmentally challenging situations and pursue new opportunities. But the evidence discussed shows that through remittances, migration also has significant effects on the adaptive capacity of families and communities that migrants leave behind (Sakdapolrak et al. 2015). Community-wide impacts are especially likely if remittances are used for local development initiatives or spent on social goods like education and health care (Babagaliyeva 2017). Additionally, migrant remittances can build community resilience if they are invested in activities that preserve natural capital such as water and soil (Scheffran et al. 2012). The size of remittances matter, however: in the Mexico Migration Project, remittances enhanced agricultural productivity only when they were “substantial” (Deshingkar 2012). Duration matters, too: households that have been receiving remittances for a longer time generally have higher adaptive capacity than those that have been receiving them for a shorter period (Banerjee et al. 2017).

In promoting initiatives to encourage remittances, proponents would do well to consider their adverse unintended consequences. Of note are the ways in which remittances could widen existing income inequalities (Scheffran 2012) and impose burdens on senders, who can struggle to make ends meet and incur debts to provide resources after disaster strikes at home (Harvey 2007). These issues aside, the impact of remittances can be strengthened through investments in innovations that make transactions cheaper, less bureaucratic, and more transparent.

## Financial Literacy

The literature on financial counseling or literacy interventions in the context of adaptation is thin. We identified four monographs, including a case study, a policy analysis piece, and an experimental study. Available studies comment on the adverse effect of natural disasters on people's financial well-being and discuss financial literacy services as a factor that enables take-up of other financial products or services known to have a positive impact on adaptive capacity, such as insurance.

Studies cite a lack of knowledge or awareness as a barrier to the use of financial services that can build resilience (e.g., insurance, microfinance, and savings), and they present financial literacy programs as a way to bridge those gaps, albeit from a scarce evidence base. That the focus of financial literacy programs is knowledge makes them complementary to other direct financial services (Carcellar et al. 2011); gains in literacy not only help boost demand for direct financial services but empower people to

make better decisions (Haworth 2016). The previously mentioned Savings for Change project includes a financial literacy component, as does the BOMA project in Kenya, where researchers found the lack of financial literacy a binding constraint to the take-up of digital financial products (Tiwari 2019).

Illustrating the role that financial literacy programs can play, one study finds that gender-sensitive financial literacy interventions helped participating households save more (Banerjee et al. 2019).

## The Opportunity

Cash transfers as well as micro-finance and savings products could build financial capacity and enhance resilience to climate impacts. These solutions place populations in a better position to withstand income shocks, preventing them from sinking further into poverty when climate-induced disasters strike (Zeigler, 2016). For rural-based populations, financial assets can act as a buffer against crop failures, allowing them navigate food shocks and maintain their regular levels of food consumption.

Community level impacts are also likely given that these tools provide for increased circulation of financial resources in local economies, generating gains in job creation and services. These community level gains could be enhanced by migrant remittances, which not only boost household resilience, but contribute to local economic development. Remittances may also be used to support community-level adaptation infrastructure when aggregated (UNEP 2016). Despite these opportunities, low-income populations are often unable to take advantage of these tools that can help build climate resilience because of low financial literacy. Given this gap, it is evident that financial literacy programming could help strengthen the reach and impact of other direct financial services in the climate resilience context.

The increased attention to financial inclusion as a driver of resilience is a welcome shift in the global conversation on financial services. On the one hand, this development ushers in much needed appraisals of the social impacts of financial services, looking beyond fundamental goals like poverty alleviation. On the other, it raises new challenges with respect to measuring financial inclusion in the context of resilience. One interviewee cited a forthcoming framework for measuring global financial health as a potential tool that provides standardized guidance on what indicators should be measured for a range of financial products deployed to build resilience. While the contribution of financial services to resilience is well documented, as expert suggested that strategies to scale up such services need to consider how to build the resilience of financial institutions to climate-related shocks, given their critical role in getting financial resources to vulnerable populations that need them.

## Unit of Intervention

All direct financial services are directed toward individuals or households—one of only two action areas in this assessment that address this smallest unit of intervention. The challenge for any new intervention is in selecting the appropriate public, civil, or private-sector entity through which to access individuals.

## Scale of Intervention

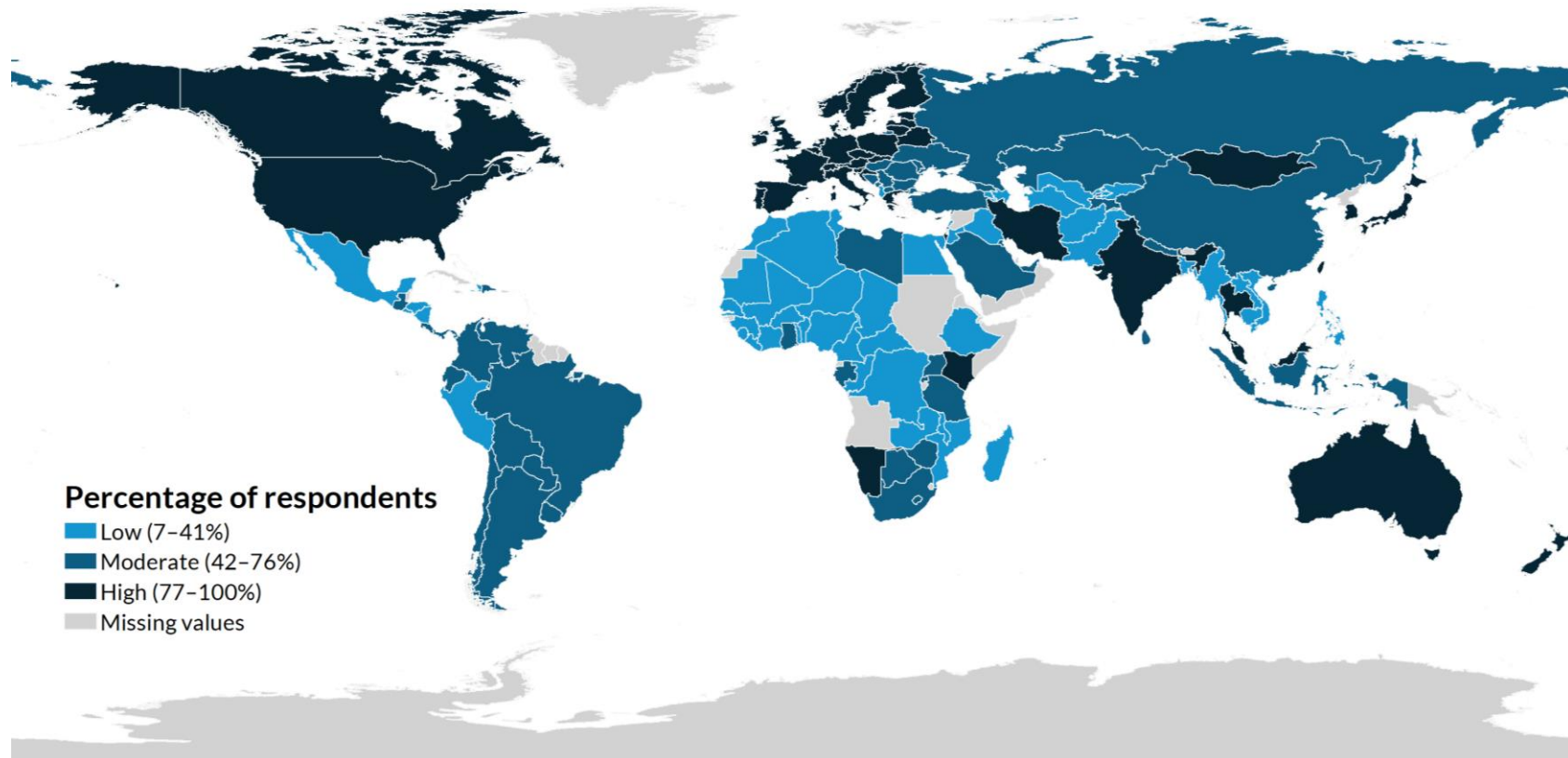
In theory, all households could benefit from resilience-focused financial services. Yet, two different scales are feasible based on the selection of strategies. For places in which secure, long-standing financial services exist such as in high- and mid-income nations, the cash transfer, savings, and financial literacy programs could be scaled for all low-income households. In other places, microfinance and remittance programs could supplement the unbanked. With the global population of financially-served households increasing, a combination of opportunities could help prepare all vulnerable populations from shocks.

The places where these financial safety net measure are most needed, of course, mirror places where there are proportions of the unbanked, and especially unbanked women (figure 17). The physical availability of banking facilities for all households (figure 18) presents a few challenges for implementing several of these opportunities, though the advent of mobile banking is slowly removing bricks-and-mortar financial services as a barrier to access. Consequently, tapping into remittance-receiving nations (figure 19) with a combination of in-person and online financial service tools could provide immediate entry points.



FIGURE 17

Banked Female Population, Share, 2017

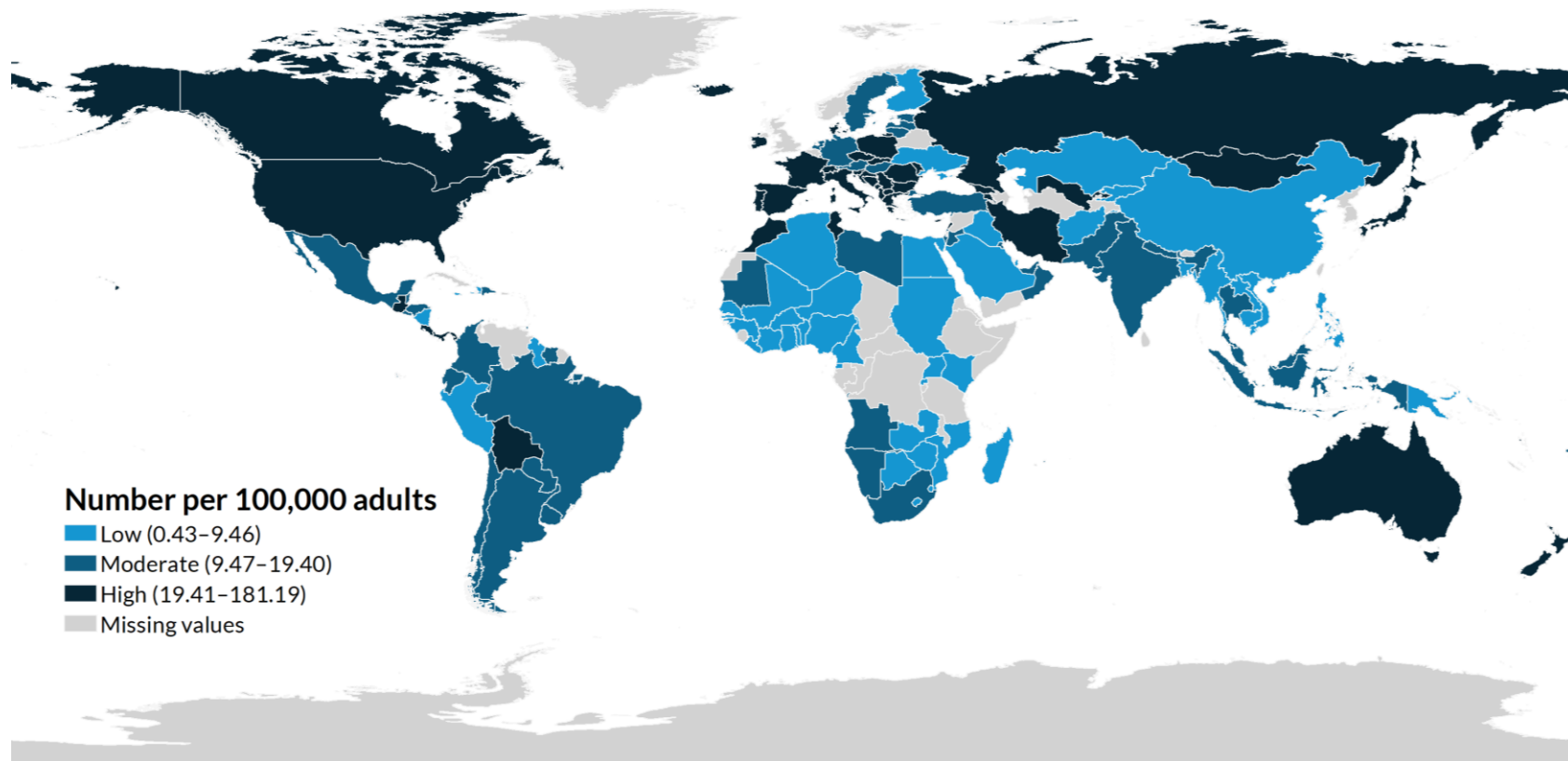


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Source: "The Global Index Database 2017," World Bank, accessed April 1, 2020,  
<https://globalindex.worldbank.org/#:~:text=The%202017%20Global%20Index%20database,62%20percent%20to%2069%20percent.>

FIGURE 18

Number of Commercial Bank Branches per 100,000 Adults, 2018

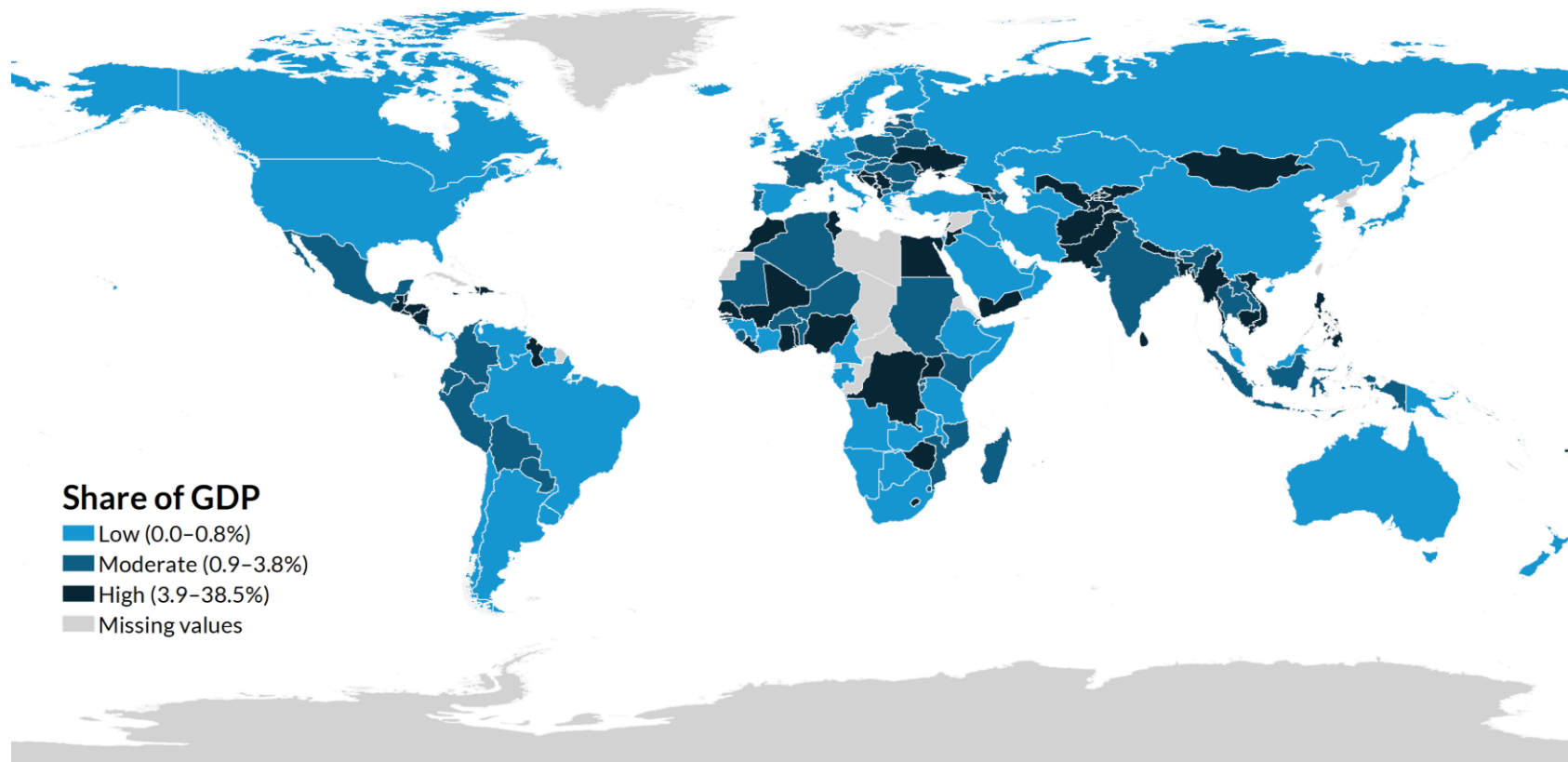


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Source: “Number of Commercial Bank Branches per 100,000 Adults,” International Monetary Fund, accessed April 1, 2020, <https://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C>.

FIGURE 19

Inflow Remittances as Percentage of National GDP, 2019



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Source: “Remittance Inflows,” Global Knowledge Partnership on Migration and Development, accessed April 1, 2020, <https://www.knomad.org/data/remittances>.

## Summary

All five categories for action in this action area have decades of successful implementation that could be used for resilience-specific objectives. Direct financial services can empower people and communities to autonomously reduce their vulnerability to climate change impacts, but the market has gaps. The solutions are applicable in diverse settings: both urban and rural, and in both advanced and developing countries. Because take-up of these services is by individuals, the ability to quantify beneficiaries is easy and immediate. However, the potential adverse impacts of scaling up such solutions need to be assessed and accounted for. These solutions also implicate partnerships with banking and related retail financial institutions, who have vested interest in not only integrating the previously unbanked or under-banked in general, but ensuring that those households can maintain credit and debt obligations after climate shocks.

Diverting financial services and financial assistance programs for specific shocks beyond general financial preparations, however, will be challenging. Yet, formulating new support and safety net programs directly addresses the most central indicator in all measures of environmental and social vulnerability: poverty.

Defined by the World Bank as part of a potential “resilience package”—or, a “set of policies that increases the ability of a population to cope with asset losses without reducing the asset losses themselves,” direct financial assistance can make the difference for vulnerable populations in surviving shocks of all kinds (Hallegatte et al. 2017). In this action area, there are many, wide points of entry to support resilience-specific transfers, savings, microloans, remittances, and literacy programs of all kinds. As these services currently exist, in fact, the one potential addition to the value of a household “rainy day” fund lies in articulating the specific resilience purpose to which they should apply.

## Notes

- <sup>1</sup> These conclusions are based on simple pre-post comparisons of select indicators and are almost certainly biased estimates of impact because of confounding factors. They have not sufficiently proved that the changes in outcomes are as significant as they claim (even if qualitatively), nor have they demonstrated that those impacts are attributable to the BOMA project.
- <sup>2</sup> Same caveat above applies.
- <sup>3</sup> According to the Food and Agriculture Organization of the United Nations, climate-smart agriculture helps guide actions needed to transform and reorient agricultural systems to support development and ensure food security in a changing climate. Climate-smart agriculture aims to tackle three main objectives: sustainably increase

agricultural productivity and incomes; adapt and build resilience to climate change; and reduce and/or remove greenhouse gas emissions where possible.

- <sup>4</sup> Citing experiences from the Building Resilience to Climate Extremes and Disasters project, Calderone and coauthors (2019) makes a special case for Islamic microfinance in the context of adaptation, pointing out that sharia-compliant options can overcome cultural barriers and expand access to such products.
- <sup>5</sup> The regression coefficients have large standard errors, suggesting that the estimates may not be accurate.
- <sup>6</sup> The identification strategy for Bangladesh, Burkina Faso, and Ghana include counterfactuals, which allows for causal claims, but the evidence for Ethiopia is suggestive at best.
- <sup>7</sup> See also Babagaliyeva et al. 2017, which suggests that a significant share of remittances in Tajikistan are spent on households' immediate needs.

# Insurance

Another frequently cited set of options for promoting resilience among individuals, local governments, and nations is the tried-and-true vehicle of insurance (Kunreuther et al. 2012). There are numerous opportunities in the general risk mitigation and sharing arena, and insurance products have been put forth as the most tested to date. Virtually all the literature points to insurance tools as a viable channel for resilience, but also one needing some innovation given the uncertainty of risks for both the insurer and the insured (Pierro and Desai 2011; GIZ 2014).

## The Challenge

The economic costs of natural disasters and other shocks have increased substantially in the past two decades. There are many likely factors for this, including rapid urbanization in flood-prone or coastal areas (an increasing concentration of people and assets, and a slower pace of infrastructure development to accompany it), environmental degradation, and a rise in the number of catastrophic events. However, only a third of these losses were covered by insurance (Baur and Parker 2015). The economic consequences are substantial. An analysis of 203 countries over 52 years found a median and mean cumulative output loss of 1.7 percent and 2.6 percent, respectively (Von Peter et al. 2012). However, it was the uninsured losses from the catastrophes that drove the overall macroeconomic costs; well-insured losses, on the other hand, had either insignificant or even positive macroeconomic effects. The impacts are most pronounced in low-to-middle income nations, suffering more when uninsured and benefitting the most when insured. Insurance can therefore play an important role.

Disaster risk management – disaster risk reduction and risk financing – is essential for climate change adaptation to diminish exposure and enhance resilience in the face of extreme climate-related events. However, there are several challenges that require awareness from practitioners. The way policy is designed is important to avoid dis-incentivizing efforts to reduce risk, also known as moral hazard; instead, disaster insurance should reduce losses and simultaneously promote preventive and risk-sharing behavior (Pierro and Desai 2011; Linnerooth-Bayer and Hochrainer-Stigler 2015). Policy design is also important for future iterations, as the level of demand for innovative insurance products may also be influenced by consumers' recent experiences with insurance (Cole, Stein, and Tobacman 2013). Moreover, insurance may not be an effective tool to address slowly-developing risks, such as sea level rise, but is instead a better tool for acute, lower-probability shocks. Premium payments are likely

to be unsustainable particularly for private insurers in areas with multiple high-loss events (Linnerooth-Bayer and Hochrainer-Stigler 2015).

It is also important not to overstate its benefits; while insurance can be an effective tool for replacing losses, it is not the best mechanism for providing substantial improvements in quality of life (Pierro and Desai 2011). The extreme poor need to address more fundamental needs, such as access to higher prices and a strong safety net before they can fully benefit from insurance (Le Quesne et al. 2017). Ultimately, disaster insurance on its own will very unlikely be effective, requires a complementary tool that also address the underlying risk factors (Pierro and Desai 2011).

The Munich Climate Insurance Initiative (MCII) recently commissioned an evidence review on the potential for insurance to contribute to disaster risk management (Le Quesne et al. 2017). The authors emphasize that insurance has a pivotal role to play in combination with broad risk management and reduction efforts. But evidence shows that insurance schemes must meet several key conditions, without which they may have no impact on building resilience capacity, or even may inadvertently reduce resilience, especially for the most vulnerable (ACRI+ 2017; Golnaraghi 2018). Key conditions include appropriateness of the insurance scheme for context and risk (e.g., frequency and severity of hazard); design of insurance tool and appropriateness for intended beneficiaries; and integration of the tool into broad disaster risk management frameworks, including layering or macro-, meso-, and micro-level insurance.

Further innovations may secure households and communities against climate risks, including innovations in the following:

- **Sovereign and municipal hazard, catastrophe, and climate insurance.** Sovereign-level insurance is cited as particularly appropriate for low-frequency, high-impact events because it can be leveraged to make financial resources rapidly available and at a lower long-term cost (Baur and Parker 2015; Clarke et al. 2015; Dercon and Clarke 2016). On the other hand, sovereign insurance may not be appropriate for high-frequency, low-impact events or long-term reconstruction; in those cases, tax-financed reconstruction may be more cost-effective (Bevan and Adam 2015).

In addition to providing necessary financial resources, sovereign-level insurance can promote expanding risk management practices at a national level by promoting accurate risk assessments, encouraging risk reduction planning, and in some cases improving disaster risk governance (Schaefer and Waters 2016). However, researchers argue that empirical evidence is needed to demonstrate an operational link between risk transfer and risk reduction,

particularly as it relates to the possibility to incentivize risk-creation behavior known as moral hazard (Schaefer and Waters 2016; Surminski and Oramas-Dorta 2014).

The Turkish Catastrophe Insurance Pool, created in 2000 to address earthquake risk, offers important lessons for scaling insurance affordability in middle-income countries. It was the first program to be implemented at a national scale and in partnership with the World Bank to absorb risk through a contingent loan facility (Linnerooth-Bayer and Mechler 2009). Similarly, the 2007 Caribbean Catastrophe Risk Insurance Facility was formed as the first multicountry, parametrically defined risk pool in the world and continues to provide financial liquidity to member countries after major shocks. Accurate risk assessments and advances in catastrophe modeling are necessary to support expansion of models such as these examples. The World Bank is exploring catastrophe bonds and catastrophe insurance in a few developing countries; however, technical and financial capacity is noted as a barrier to scale (Le Quesne et al 2017).

- Parametric and cooperative **property “climate” hazard insurance**. Risk-based pricing for property insurance is viewed in the literature as an opportunity to increase awareness of risks and encourage individuals and households to reduce risk through the incentive of lower premiums (Herweijer, Ranger, and Ward 2009). However, scholars note that in practice, many factors determine premiums, including operational concerns, profit motives, and competition, which means that risk-based premiums may not accurately reflect risk (Doherty et al. 2008).

Research suggests that risk-based property hazard insurance models can be strengthened through opportunities to illustrate loss reduction based on specific adaptation measures (Lloyd’s of London 2012). Risk reduction frameworks can help with the overall affordability of insurance, making it more accessible for the global poor (MCII 2016).

Emergent insurance models such as pilot products in Peru and Vietnam use climate indices to forecast hazards and provide funding before climate effects. The mechanism encourages recipients to use insurance payments to reduce risk—for example, to clear drainage systems before heavy rainfall. Evidence demonstrates the value of linking forecasts, insurance, and development investments in joint mechanisms for individual and community outcomes (Carriquiry and Osgood 2012; Osgood et al. 2008). Similar models develop contingencies based on participation in risk reduction activities. However, considerations for the most vulnerable communities would need to be incorporated into these models as people with low incomes may not be able to respond to incentives for risk reduction and in turn may be charged higher fees (Surminski and Oramas-Dorta 2014).



- **Household and property microinsurance.** Microinsurance’s potential to help people living in poverty—in both urban and rural settings—mitigate the effects of climate shocks and protect limited assets is broadly recognized in the literature (Kloppinger-Todd 2010). An opportunity exists to replicate widespread take-up of life and health microinsurance in developing countries with microinsurance applications related to risk (Morelli et al. 2010; Loster and Reinhard 2012). As described in more detail in the chapter on food security, microinsurance in agricultural settings can be applied to crops, livestock, credit, inputs, revenue, bloodstock, forestry, and greenhouses to secure farmer livelihoods despite increased climate risk and to promote climate change adaptation in the agricultural sector (Suarez and Linnerooth-Bayer 2010; Hess and Hazell 2016).

The potential for success of insurance take-up at the household (or micro) level is contingent on community education and increased financial and climate literacy; research shows those with less literacy on these topics are less likely to participate in insurance markets (Gaurav et al. 2011; Cole Stein, and Tobacman 2013; Isakson 2015; Le Quesne et al. 2017). Furthermore, research in both advanced and developing economies show that willingness to pay for insurance is typically well below fair price—which may reflect low uptake rates (Le Quesne et al. 2017).

The type of insurance vehicles and their feasibility in different economic contexts are also important. Indemnity (payout determined by damage to insured asset; most common in advanced economies) and index (payout determined by proxy; most common in developing country context) insurance schemes are recognized as the current models with most potential for scale (Le Quesne et al. 2017). Index-based insurance schemes are bolstered for microinsurance models in developing countries due to lower transaction costs and quicker payments. However, researchers note that basis risk is a challenge for index-risk insurance schemes as it is more likely for the pay-out to differ from loss incurred compared to indemnity models. Therefore, there are opportunities to improve proxies and data availability for index-based models. MCII recognizes actively reducing basis risk as a key principle to create client value and promote uptake of pro-poor insurance products globally (MCII 2016).

In addition to traditional cash payouts, there are opportunities for microinsurance delivery through alternative distribution channels such cooperatives, safety-net schemes and health care providers, among others (Le Quesne et al. 2017). These “natural aggregators” are identified as key to improving accessibility of insurance products from a pro-poor approach and research suggests they are a good alternative to in-kind humanitarian aid (Dercon and Clarke

2016; MCII 2016). More research is needed to understand the gender dynamics of disaster risk insurance at the micro-level. Research suggest that women could play a key role to ensure the desired risk-reduction outcomes of insurance are achieved, however programs would require specific gender targeting to address allocation of resource issues at the household level (ACT 2016).

- **Health insurance.** A recent entry into discussions of preventive measures for climate adaptation in the insurance arena are about “health systems” (WHO 2018). Much attention has been paid to the environmental health challenges associated with climate on public health organizations. Yet few solutions have emerged regarding (1) the capacity of health service providers to address challenges or on (2) the ability to pay for services—two major components of national health systems. Health insurance expansion to vulnerable populations and coverage for climate-related health effects may be one feasible, scalable strategy beyond the current infrastructure improvements that multilateral health professionals suggest.

## The Evidence

The literature on innovations in insurance policies as well as their effectiveness are largely constrained by the proprietary nature of insurance data. Insurers, reinsurers, and related service providers typically retain and update extensive actuarial tables along with valuation techniques and claims procedures that must respond to a wide variety of local insurance regulations and are therefore tightly guarded.

Regardless, Urban researchers explored the evidence base in the four following categories to identify possible opportunities.

### Sovereign and Municipal Hazard, Catastrophe, and Climate Insurance

We identified twenty-two relevant monographs, eight of which are scholarly exploratory studies, seven are advocacy monographs, six are policy analyses, and one is a case study. These monographs cover how governments have developed insurance pools to transfer risks through various tools, providing them a fund to tap into in times of a disaster.

During disaster events, the demands on government budgets become acute, and sovereign risk financing schemes can ensure multiple benefits, including guaranteed access and speedy delivery funds, reductions in government liabilities during disasters, diversified funding sources, and certainty for short- and long-term budget planning (Baur and Parker 2015). This is important because across the

world, governments become the insurer of last resort during disaster events. Governments should therefore be better prepared financially, with both traditional and nontraditional insurance tools, so that they can respond to catastrophes (Michel-Kerjan et al. 2011). These kinds of macro insurance policies become easier to implement (relative to micro policies) because they require relatively few entities to insure and cover only severe, less frequent disaster events (Pierro and Desai 2011).

The Turkish Catastrophe Insurance Pool was the first national insurance program developed through a PPP that addresses the potential insolvency of private insurers when addressing frequent high-loss events and reduces the government's fiscal exposure. The program was developed to cover earthquake events in urban areas through mandatory private contributions and is guaranteed by government and donors (Linnerooth-Bayer and Hochrainer-Stigler 2015).

Countries have also developed national index-based insurance programs. Ethiopia piloted the first one in 2006 to protect the agricultural sector against droughts. The scheme, which was generally considered a success, was insured by AXA Re, and the World Food Program paid the premiums. While a premium-payout analysis suggests that in the long run such a scheme may be unsustainable, scholars suggest that the timeliness and reliability of payouts during a disaster is an important benefit that countries should consider (Linnerooth-Bayer and Hochrainer-Stigler 2015).

Large countries are better able to access the capital necessary to recover from catastrophic events because unaffected areas can effectively subsidize affected areas (Linnerooth-Bayer and Hochrainer-Stigler 2015). This approach is more difficult for small island nations. The first multinational disaster insurance scheme was implemented in 18 countries of the Caribbean in 2007. Using parametric insurance schemes (based on indices such as wind speeds or strength of earthquakes), the Caribbean Catastrophe Risk Insurance Facility streamlined the loss assessment process and therefore could provide payouts quickly (Baur and Parker 2015). By pooling their risk, the 18 countries jointly saved 40 percent in individual payments for premiums.

Catastrophe bonds are another approach to managing disaster-related risks that many authors cited. Catastrophe bonds are financial securities linked to an insurance-related risk that are triggered during a disaster event. Investors can obtain high interest rates to offset the relatively high risks associated with these bonds, and the bond issuers can have access to capital to deploy during catastrophes (Re:focus Partners LLC 2015). One example that many scholars highlighted was Mexico's MultiCat scheme, which was developed in 2009 for hurricanes and earthquakes (Michel-Kerjan et al. 2011). The MultiCat program pooled multiple risks and covered multiple regions and perils. For such a scheme to be effective, ensuring that the right location is insured and that the right trigger is used is

important. Also, working with key partners in designing the scheme is essential. In the case of MultiCat, the partner was the World Bank, and the program provided a framework that other countries partnering with the bank could use (GFDRR 2013).

## **Parametric and Cooperative Property Insurance**

We identified thirty-two monographs relevant to this area; three are quasi-experimental, eight are policy analyses, seven are case studies, six are scholarly exploratory studies, and eight are advocacy monographs. These highlight the importance of appropriate risk assessments and policy design to avoid moral hazard, the proper role of both government and the insurance sector, opportunities to scale insurance schemes, and the potential for a more integrated approach to address the vulnerabilities that underlie risk.

Parametric or index-based insurance is insurance against an objective measure known to influence losses, such as rainfall or wind speed. Weather index-based insurance function based on indexes correlated with local yields (such as a drought or heat wave). Because indemnifications are based on the index instead of actual yields, in-field assessments are not necessary (reducing administrative costs). Individuals pay the same premium rate, eliminating issues of adverse selection and moral hazard. Therefore, this kind of insurance can serve not only as a protection against losses during extreme events but as a tool for development by guarding investments (Hazell et al. 2010). The primary benefit is the quick payouts to the insured to help them recover quickly from a shock (Jarzabkowski et al. 2019). However, payouts in some cases do not match the actual losses incurred because of low-quality data to evaluate risks and premiums. The primary opportunity in this space is therefore to improve the connection between the scientific community and the insurance industry so climate change models can be used to more accurately reflect risks (García Romero and Molina 2015; Woetzel et al. 2020).

To ensure the scalability of such schemes, policymakers and investors should consider that developing products that are high-quality in areas where data are scarce will likely increase costs for providers and see little take-up (Jensen and Barret 2017). A good marker for investments is whether a community with frequent shocks has alternative social protections. When they are lacking, the high costs of developing an index-based insurance scheme can be worth it and will improve the lives of those being served. Moreover, efforts should go toward raising the credibility of these schemes. Agricultural workers in Bangladesh found index-based insurance to be conceptually complex; the demand for insurance was low, particularly among women, who were found to be more risk-averse (Akter et al. 2016). Scalability is essential and requires a holistic approach, including the proper regulatory

environment, distribution channels, and insurance scheme design to fit the needs of the target community.

Several countries have piloted weather index-based insurance, including Brazil, Canada, China, Ethiopia, India, Indonesia, Jamaica, Kenya, Malawi, Mali, Mexico, Mongolia, Nicaragua, Peru, the Philippines, Rwanda, South Africa, Tanzania, Thailand, Ukraine, the United States, and 16 Caribbean countries (Kreft, Schaefer, and Behre 2017).

Scholars also called for a more integrated approach to resilience and risk. The World Bank suggested that risk assessments should cover more than hazard impacts, including institutional and socioeconomic factors (Dickson et al. 2012). There are also considerations about not only managing risks but addressing the factors that are causing the risk (Le Quesne et al. 2017). Particularly for properties in coastal regions affected by sea level rise, the insurance industry can play a vital role in making sure that premiums adequately reflect risks, which can encourage property owners to take the proper adaptation measures to reduce their insurance rates (Lloyd's of London 2012). Reducing vulnerability and exposure through investments in physical infrastructure for flood protection or adapting properties to be more resilient to weather hazards can in turn reduce the potential insured losses (Coughlan de Perez et al. 2014; UNISDR 2015; Herweijer, Ranger, and Ward 2009). Because these measures raise the “insurability” of properties and assets, opportunities for reinsurance will likely expand and thereby expand the availability of insurance. An important area for additional research is how to balance the apparent trade-off between risk-based pricing, affordability concerns, and the associated political will to push for these kinds of policies (Golnaraghi, Surminski, and Schanz 2016).

## **Microinsurance**

Microinsurance was part of the late 20th century's microfinance boom and has resurfaced in both development and insurance circles in response to the increase in natural hazards, agricultural shocks, and chronic climate change-induced conditions like drought and heat waves. We identified seventeen recent monographs as relevant to this area; two are quasi-experimental, three are advocacy monographs, two are case studies, seven are policy analyses, and three are scholarly exploratory studies. Most of the literature explores microinsurance strategies for people with low incomes working in the agricultural sector and highlights the challenges of developing an insurance policy in areas without adequate infrastructure and a baseline capacity.

The effects from climate change on the agricultural sector are likely to be highest in developing nations close to the equator, with potential reductions in revenue of 12 to 50 percent (Romero and

Molina 2015). These effects disproportionately affect people living in extreme poverty because their lack of social protections leaves them highly exposed and with a lower capacity to cope (Schäfer et al. 2016). Market failures, such as information asymmetries and high transaction costs, have prevented insurance markets from fully developing in these countries.

Microinsurance exists to avoid the high costs of traditional insurance when serving the poor (Linnerooth-Bayer and Hochrainer-Stigler 2015). Le Quesne and coauthors (2017) describe microinsurance as “extremely diverse,” allowing the schemes to be tailored to community needs. A distinctive feature of microinsurance is that the policyholders are legally entitled to compensation. Broadly, microinsurance can be based on the actual losses from a shock (indemnity-based) or based on an index that reflects triggering events that cause losses (Linnerooth-Bayer and Hochrainer-Stigler 2015).

Multiple publications reported that successful microinsurance situations are when the schemes can not only insure loss but promote risk-reducing behavior. The R4 Rural Resilience Initiative in Ethiopia, Malawi, Senegal, and Zambia is an index-based microinsurance scheme for extreme weather events or climate-related shocks. R4 has reached more than 87,000 farmers with a total of \$10.3 million through 2019 by providing a comprehensive risk management approach while promoting risk-reducing activities.<sup>1</sup> Farmers can buy weather index insurance against drought, and a sample of farmers were encouraged to collect rainfall data to be more responsive to changes in rainfall patterns. Farmers could also “work for their insurance cover” by engaging in risk-reducing activities that were identified by the community, such as better social management or improved irrigation practices. Farmers had the opportunity to use their savings or stocks to apply for credit; those who were insured could increase savings by 123 percent more than the farmers who were not insured (Schäfer et al 2016). Finally, R4 created risk reserves, or group savings, within communities, a form of self-insurance.

Microinsurance providers can improve their operations by building managerial and staff capacity, making processes more efficient, and improving the overarching business model. However, certain conditions in developing countries are necessary for microinsurance to flourish, such as stable economies, developing financial markets, an agenda for creating an insurance market, and robust health care quality (Loster and Reinhardt 2012). To promote such conditions, developing nations and regions require an expansion of technology so insurance options are accessed through tools like computers or cell phones; public awareness efforts so people understand microinsurance’s benefits and can distinguish between microinsurance and other social protection programs; and the incorporation of climate change and its impacts in long-term plans.

## Health Insurance

Basic health coverage and policies are not included in most resilience insurance conversations. But considering the possible shocks a household faces—from hurricanes to heat waves and pandemics to plagues—and the likelihood of related health impacts, health insurance (as distinct from health care and health providers) is a crucial tool. Both the resilience (especially climate adaptation) and the safety net literature identifies health insurance as a potential solution, but surprisingly little literature explores the nature of insurance coverage and access for climate change's specific effects on human health. We identified only five recent monographs—two policy analyses, two advocacy monographs, and one scholarly exploratory study—that do so. The papers highlight the strong link between climate change, air pollution, and public health, as well as the health benefits associated with addressing climate change. The papers also highlight the importance of improving the health care system overall for health insurance to be of value to communities.

Access to health care that is high-quality, equitable, and transparent is essential, particularly in rural areas, where health care is less available. Each year between 2030 and 2050, climate change is expected to add 250,000 deaths from diarrhea, heat stress, malaria, and malnutrition.<sup>2</sup> Weather events such as heat waves, droughts, floods, sea level rise, and air pollution can lead to heat stress, injuries, malnutrition, respiratory diseases, and mental health conditions.<sup>3</sup> This trend disproportionately affects developing countries that lack a strong health infrastructure.

Health insurance has many of the issues of other insurance schemes, such as moral hazard considerations and the difficulties that arise when financial education is low. Although insurance is understood to be an effective tool to promote resilience to low-frequency, high-cost events, insurance can be more difficult to address health-related events because of the complexity of obtaining information for claims' verifications. A health insurance scheme that is viable, particularly in low-income areas, can be greatly improved by including the community in business processes to align the interests of the insurers and the insured. Therefore, experts highlighted the importance of community-based health insurance (Loster and Reinhard 2012). Like other insurance schemes, community-based health insurance promotes sharing risk and pooling resources but is generally run by a nonprofit to ensure that beneficiaries participate in the decisionmaking processes. As such, the risks are carried by the insured, who are also the scheme's owners, and gains are aligned with the interests of the community, lowering the costs from adverse selection and moral hazard. There are concerns, however, that as these insurance schemes scale, the sense of both personal and mutual responsibility decreases.

Improving health care monitoring systems is also important so insurers can understand risks, especially in low-income areas; health-related data are more available from people with higher incomes who can access formal health care, as opposed to informal mechanisms. More and better data will improve the basis on which providers calculate premiums and the ability to target low-income communities (Loster and Reinhard 2012). The health care system must also become more resilient to climate-related events (WHO 2018). Hospitals are beginning to incorporate climate resilience in their operations to be better prepared to serve patients during disasters.<sup>4</sup>

## The Opportunity

As a sector with a long and geographically diffused history, insurance provides numerous opportunities for exploration. However, these opportunities are all challenged by the same reality: insurance is a highly regulated and policy-constrained space in virtually all countries in which it is uniformly utilized. Consequently, this review of four action areas reveals some opportunities to tweak with current insurance tools in developed contexts, while suggesting pilots and demonstrations for providing entirely new insurance vehicles in developing ones. There are ample immediate opportunities for both contexts across three of these areas, with health insurance being a much larger and more complex enterprise.

In sovereign or municipal insurance, for example, both research and experimentation could be used to help design multinational risk pools in regions with strong economic and historical ties and limited individual insurance capacity, such as the efforts already seen in the Caribbean. Multilateral organizations could then serve as backstops for the policies of lower-income regions while the re-insurance markets can continue to serve wealthier nations and regions. For both cases as well as dozens of others noted in the literature, the best entry point is likely in convening appropriate stakeholders and encouraging research and design of potential instruments between public and private entities.

A similar strategy could be employed for property insurance and microinsurance. For the former, however, individual nations and subnational governments tend to play a dominant role in setting the terms and policies for private insurers (and, in some cases, public insurers such as the National Flood Insurance Program and state's wind and earthquake insurance pools in the US). This action would require extensive place-based activity and would be reserved for high-population, high-vulnerability regions without existing insurance infrastructure. In those cases, the development of means-tested insurance subsidies could serve to promote private insurance while still providing a necessary safety net for lower-income, vulnerable households.



For the latter (microinsurance), working with existing cross-national microinsurance providers and other civil-sector funders could provide necessary discussions and program designs for bringing uninsured and under-insured households into coverage, like the ways that early microfinance institutions successfully developed services for the unbanked and linked these to formal banking and financial institutions in their respective countries. Opportunities for convening the appropriate stakeholders, resourcing researchers in scholarly and private institutions, and then piloting insurance schemes in the appropriate development and political contexts could be the most efficient entry points in these categories.

Obvious partners exist among insurers and re-insurers. They have a central role in leveraging information and competencies to help private and public sectors with climate change adaptation. This includes: research and cost-benefit analyses, risk assessments and risk pricing expertise, innovation in risk transfer services, identifying strategies and opportunities for risk mitigation, and promoting policy changes such as improved building codes (Herweijer, Ranger, Ward 2009; Geneva Association 2018). Additionally, insurers are uniquely positioned to educate their customers about risk exposure. However, insurers often limit access to risk information which is viewed as a proprietary part of business model. Increased access to this information as a public good is necessary to yield many of the benefits listed above (Le Quesne et al. 2017).

According to experts in the field, insurance is a critical lever to address urban resilience, but only when integrated into a broader risk management approach that brings to together accurate risk information and supporting land use and building codes with accompanying enforcement mechanisms with the protective layer of insurance. This integrated approach is critical as disaster insurance is complex and expensive, with affordability of disaster insurance products viewed as the primary challenge. Stakeholders reflected that absence of a robust private disaster insurance market means that public action is necessary to scale disaster insurance. Governments could develop means tested insurance products to address specific insurance gaps, especially for low-income households. The availability of disaster insurance products would need to be coupled with greater household level understanding of risk, as discussed in the education section. Philanthropic efforts for insurance could support exploratory work harnessing private and public sector financial recovery vehicles by leveraging the private sector contributions.

## Unit of Intervention

The insurance action area maps out onto the widest range of units of interventions: multi-national regions and individual national and subnational geographies, and individual households and properties. The units of intervention of insurance depend largely on what is being insured.

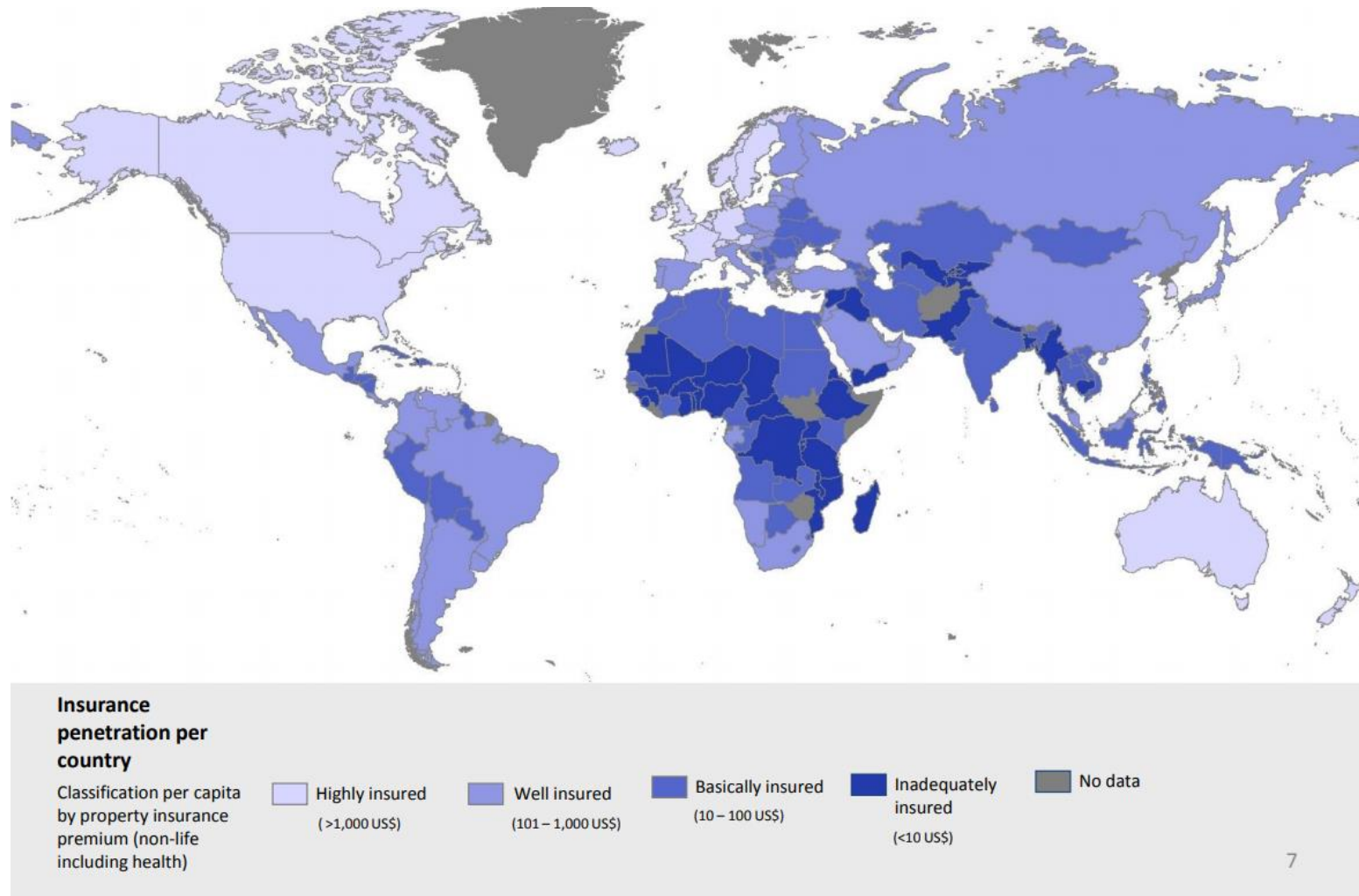
## Scale of Intervention

Consequently, the range of populations that would be directly affected if an opportunity is implemented and then scaled (and indirectly by actors that replicate the opportunity) will also vary depending on whether national or individual insurance opportunities are seized. Not coincidentally, nations with low rates of private insurance penetration tend to be lower-income nations without regulatory mandates for holding policies and challenges in asset valuation (figure 20).

In either case, the best likely targets for piloting and expanding solutions lie in the middle-income countries with some history and infrastructure for insurance policies but only modest regulatory frameworks. As identified in the literature, places like Ethiopia, Kenya, Tanzania, and South Africa in Africa; several Caribbean and Latin American nations such as Brazil, Jamaica, Mexico, and Peru; and South Asian nations including India, Indonesia, Philippines, and Thailand are ideal pilot sites for all opportunities regardless of intervention.

FIGURE 20

Insurance Penetration, 2014



**Source:** Reproduced from "Climate Risk Insurance for the Poor and Vulnerable: Principles for 'InsuResilience'" (Presentation of Peter Hoeppe during the Munich Climate Insurance Initiative side event, Bonn climate talks, May 2016).

## Summary

The four categories defined in this action area represent a growing area of global interest and activity as a general solution set for building resilience since insurance is a direct mechanism for pooling risk and insurance providers are well-prepared to manage and study it. Because authority over places, property, and people is managed at so many different scales, further, there are multiple types of insurance policies and categories of the insured already. Insurance has been the shock mitigation strategy of choice for centuries in the developed world.

Well-designed insurance policies and uniform take-up, as part of a disaster risk management framework, can also incentivize other resilience-building activities and offers a crucial safety net following shocks (Schäfer et al. 2016). Use of insurance, including the payment of premiums before disaster is beneficial for budget planning and economic stability for households, business and governments alike (Baur and Parker 2015). Furthermore, middling evidence suggests that insured losses may have positive effects for GDP growth, in addition to avoiding harm to economic growth (Von Peter et al. 2012). There is a paucity of evidence on the cost-effectiveness of insurance (and accompanying opportunity cost of premiums) vis a vis other disaster risk financing instruments over time, attributed to difficulty identifying appropriate counterfactuals for further study (Le Quesne et al. 2017).

Despite the recognized potential for insurance as a tool for resilience, insurance against certain kinds of shocks, such as those associated with climate risk, is not widely available or used, especially for vulnerable populations in developing countries. One recent estimate found that a mere 100 million people in Asia, Africa, and Latin America were directly or indirectly insured against climate risks (GIZ and BMZ 2015). Moreover, from 1980–2015, in lower-middle and low-income countries, only 2 percent of losses due to weather-related catastrophes were covered by insurance.<sup>5</sup>

There is growing interest by national governments in market-based insurance as a resilience-building and risk transfer tool. Many insurance programs have been developed under pilots and further collaboration—between governments, policymakers, standard setting bodies, and insurers - is needed to scale (Geneva Association 2018). A review of Nationally Determined Contributions to the adaptation goal of the Paris Agreement revealed that climate risk insurance featured prominently for 38 countries representing more than 4 billion people (MCII 2017). Insurers are similarly placing increased attention on scaling climate insurance. A study by the Geneva Association (2018) interviewed top executives who emphasized need for cross-sector collaboration. Key challenges to scaling climate insurance products, as identified by insurance executives, include: access to information for accurate risk pricing; policy,

regulatory and legislative issues; limited awareness about insurance; weakness of domestic markets; limited take-up of hazard insurance; and inconsistent regulatory barriers.

As such, the potential exists for improving insurance in ways that accurately assess risk, equitably distribute it, and effectively manage it when it manifests in actual shocks. However, well-designed interventions into these opportunities must consider the wealth of extant work and stakeholders.

- Convening key stakeholders, including private insurance providers, in discussions for expanding sovereign and shared multinational insurance policies; property and hazard or shock insurance; and microinsurance is a feasible and realistic entry point.
- Funding research and pilot testing with the appropriate partner (multilateral organizations, national or subnational governments, and private insurer and re-insurer or financial institution) could establish a model as well as lessons for similar efforts.
- Advocating for improved data sharing and consistent schemes between public regulatory agencies and private insurers such that alternatives pooled sovereign insurance, means-tested insurance subsidies, and microfinance provision are clear and replicable.

Making insurance an even more resilient solution during current changes in external context (e.g., climate change) and internal transformation in the insurance industry is a critical act that can improve service for the already insured—and ensure the resilience of the previously uninsured.

## Notes

- <sup>1</sup> “The R4 Rural Resilience Initiative,” World Food Programme, <https://www.wfp.org/r4-rural-resilience-initiative>.
- <sup>2</sup> “Climate Change and Health,” World Health Organization, February 1, 2018, <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>.
- <sup>3</sup> “Climate and Health,” Centers for Disease Control and Prevention, last reviewed September 9, 2019, <https://www.cdc.gov/climateandhealth/policy.htm>.
- <sup>4</sup> Alice Chen and Vivek Murthy, “How Health Systems Are Meeting the Challenge of Climate Change,” Harvard Business Review, September 18, 2019, <https://hbr.org/2019/09/how-health-systems-are-meeting-the-challenge-of-climate-change>.
- <sup>5</sup> Munich RE, “Natural Catastrophe Losses at Their Highest for Four Years,” January 4, 2017, <https://www.munichre.com/en/company/media-relations/media-information-and-corporate-news/media-information/2017/2017-01-04-natural-catastrophe-losses-at-their-highest-for-four-years.html>.

# Education and Awareness

Compared with the physical and fiscal interventions of the previous four action areas, social interventions have received far less systematic support. With the sole exception of emergency alert systems, opportunities to build social capital; disseminate crucial information; include vulnerable communities across gender, race, and assets; and elevate dialogue for collective actions have been underresourced and underimplemented.

## The Challenge

Awareness of individual, institutional, and community-wide risks such as those from climate change's effects and other environmental hazards and shocks is minimal, though increasing. Traditionally, climate risk information has been disseminated using fear-based messages, often as post-disaster imagery portraying extreme outcomes of widespread death and loss (Frumkin and McMichael 2008). But more recent findings find campaigns that motivate fear are less effective in increasing disaster risk awareness at the individual level (Muzenda-Mudavanhu et al. 2016). In addition, even if education and awareness campaigns help build knowledge of climate risk within households, they may not directly improve a person's coping capacity, which is critical for resilience. Policymakers must develop new techniques for awareness and deploy proven tools and strategies for a wider population that use diverse multi-modal approaches.

Education and awareness of risks—especially environmental ones—has been a challenge for numerous reasons. A dominant factor in knowledge exchange has been the movement from indigenous understanding of natural phenomena to scientific, empirical documentation and projections. Climate investments and resources have also teetered between national platforms and risk communication instruments and community-based participatory approaches tailored for specific groups. As societal norms and responses have waned, new techniques have taken their place: alert systems, national campaigns, school curriculums, cultural productions, and other awareness tools. Throughout, equitable and inclusive access to information, trust and reliability in the source, and actionable messaging have been key components of the challenge.

With climate risk awareness, there can be additional complexities associated with (1) the current imprecision of risk projections; (2) campaigns that are not consistent or convey misinformation; (3) electronic social media that oversimplify and overlook important details; and (4) information mediums

that are less translatable across multiple groups. A coupling challenge to creating awareness is understanding the effectiveness of these activities on scaling appropriate solutions. Many countries around the world, including lower-income developing countries, have made national investments in education and awareness campaigns. They have disaster preparedness protocols that establish early warning systems (EWS) and determine how to share awareness more broadly. Yet the exploration of how effective these tools are in improving outcomes at the national and individual levels has been limited. This is in part due to the varying levels of coordination awareness-building requires and the availability of resources in different contexts.

Literature from both hazard and climate scholars focuses on building familiarity with the broader climate crisis as well as individuals' personal risks and opportunities. Public awareness is noted as a crucial component to any other climate adaptation solution as well (Klein et al. 2000). One benefit of awareness-building and education is that it can target specific groups in ways that improve other social disparities, such as gender inequality, poverty, political power imbalances, and the historical disregard for local and traditional knowledge (IPCC 2014). However, little exploration of how that awareness is created and the effectiveness of various awareness-building activities hampers scaling of appropriate solutions. Several solutions also point to the need to overcome questions of whether education and awareness campaigns matter for inclusion and representation in community decisions. Key challenges in this category are the following:

- **General risk awareness**, including technology-enabled platforms and storytelling media. Klein and Tol (1997) identified improving societal awareness and preparedness as a crucial adaptation component and offered actions such as public information campaigns regarding future risks and EWS for immediate disaster risks. Evidence indicates that uncertainty about climate change's effects often combines with individual perceptions and social norms about risk (Oppenheimer and Todorov 2006). Existing opinions, beliefs, values, and fundamental human cognition influence judgment and decisionmaking concerning climate change (Grothmann and Patt 2005; Moser 2005).

Additional work in this area has been developed by such groups as the Yale Program on Climate Change Communication and Climate Central, with some preliminary evidence of effectiveness. The inability of fear-based educational campaigns to generate changes in perception or behavior, for example, has been confirmed through a wide body of generally rigorous work (Moser and Dilling 2004). The role of individual actions such as those noted in this paper, however, has not been tested sufficiently, though visualization techniques appear to show promise (Nicholson-Cole 2005; Sheppard 2005).

Recent research explores the barriers to communicating about climate change and other shocks to generate behavioral changes, including the challenge of explaining the range of potential impacts (Frumkin and McMichael 2008; Moser and Dilling 2007). Early findings from this collective body of inquiry suggest that a core set of messaging characteristics appear to affect changes, such as the quality of information quality, including its specificity; the consistency in its use and the sources; and the repetition and reinforcement of the information it conveys (Mileti and O'Brien 1992; O'Brien and Mileti 1992; Mileti and Fitzpatrick 1993). Messages in question include everything from immediate disaster alerts to slow-onset climate changes.

- “Hot spot” location **targeted outreach and engagement** techniques—for example, to educate on a specific solution or tool or, even more urgently, to provide timely alerts during emergency scenarios. One challenge to general awareness building is that educational levels vary widely across communities and even within countries (Leichenko and O'Brien 2002; Dow et al. 2006; Smit and Wandel 2006; Ziervogel et al. 2006). Interpretations of the danger and risk associated with climate change are context-specific (Lorenzoni et al. 2005). As such, some research suggests that a messaging focus on the personal risk of specific damages of climate change can bear motivational and behavioral fruit (Leiserowitz 2007). Risk messages then must be specific (Mileti and Sorensen 1990; Mileti and Peek 2002).
- The use of citizen scientists, **local knowledge**, and indigenous solutions to help bridge awareness gaps. As noted in multiple global climate reports, successful community-based disaster risk reduction and climate adaptation are predicated on the empowerment of community members (Adger and Kelly 1999; Polack 2008; Hewitt 1997). A core component of empowerment is the respect allotted to community structures and traditional and local knowledge systems (Petal et al. 2008; Wisner et al. 2004), as well as knowledge sources that are often overlooked, such as the poor, women, the indigenous, and ethnic minorities.

The consensus among researchers is that regardless of the tool, the community, specifically the people most at risk to disasters, need to be involved in the planning process. There are numerous examples of ways in which a governing body can engage with their communities, but most of the focus within literature is on the methodology of engagement and making sure that the community understands the risks and their options for resilience. Some work suggests that numerous opportunities exist for shaping specific climate adaptation solutions (such as infrastructure choices, financial services, insurance products, and educational campaigns described in this report) in ways that integrate local knowledge and encourage the exchange of



information “from the bottom up and from the top down” (Burton et al. 2007; Prabhakar et al. 2009). Many of these opportunities exist simply by identifying what many local groups are already doing (Cabrera et al. 2008; Langsdale et al. 2009).

- The ability of the **arts and other cultural productions** to inform communities of broader risks and resilience-building actions is unclear, though promising. Considering the range of other socially crucial topics that have surfaced in the popular conscience because of the range of discreet to explicit artistic media, resilience opportunities seem overlooked.

## The Evidence

The literature on recent innovations in communicating to broad populations about risk and resilience and effectiveness of communication campaigns has dramatically grown in the past three years. This might be a result of the increase in shocks such as hurricanes, typhoons, and wildfires (and a growing acceptance of resilience messages) and the reflection of these events in both popular and artistic media through newspapers, TV, radio, and even artwork. Urban researchers explored the evidence base in the four following categories to identify possible opportunities.

### General Risk Awareness

We identified 33 recent studies that appraise local and national initiatives related to general awareness of the risks posed by shocks, especially climate change. Almost all the studies demonstrate that public awareness of disaster risk reduction and education are important components of effective risk management of natural catastrophes. Seven studies indicate that behavior change can come from key messages that are consistent, culturally appropriate, context-specific, and localized. Seven studies highlight how education—mostly formal (in school), but also informal (in the community)—can improve knowledge of hazards. However, many studies emphasize that ensuring people are receptive to climate change messaging is crucial; without self-efficacy, a clear understanding of consequences, and foundations of accurate information, community members, particularly young people, are unaware of disaster preparedness. Three studies found better preparedness for hydrogeological risks such as flooding, droughts, and landslides than other disasters. Two studies found that fear-based campaigns are not the most effective in educating youth. Finally, eight studies mentioned that training and capacity building can strengthen government so that it can better communicate about risk awareness through the media, web-based platforms, and national campaigns.

Explaining the range of potential impacts from climate change remains challenging. Efforts to encourage adoption of pro-environmental behavior, which includes both awareness of how to reduce disaster risk and actions to do so, require several strategies, including information dissemination through education and training, access to financial resources, safeguards for livelihood security, and other incentives that can ease the shift (Yu et al. 2020).

To effectively induce change, messaging that describes climate change effects must be clear to diverse audiences, particularly because risk exposure is variable—some people and places are more vulnerable than others (Howe et al. 2019). The medium of climate change communication can influence which methods, tools, or approaches are adopted and by which communities (Filho et al. 2019). Messaging that frames fearful representations of climate change risks and uses worry to drive action has been a predominate communication mode in the climate change community (Yale Program on Climate Change Communication). But worry- and fear-based campaigns have not been effective levers for increasing awareness and encouraging preparedness; instead, readiness to better plan and capacity to cope with risk depend on a person's access to resources, level of political engagement, and support through their social networks (Muzenda-Mudavanhu et al. 2016; Frumkin and McMichael 2008). Young people, who are particularly vulnerable to the effects of climate change, require clear messaging and constructive engagement, such as affect-driven approaches, that educate them on choosing appropriate responses; didactic approaches have been largely ineffectual (Rousell and Cutter-Mackenzie-Knowles 2019). However, there is still limited research on best practices and studied approaches that help determine strategies to involve youth's cognitive awareness on climate change effects and how their coping capacities are affected through general risk awareness (Rousell and Cutter-Mackenzie-Knowles 2019).

Building awareness of risks to health and personal property, particularly from recurring disasters, is important for the general population and is especially so for the educators disseminating or developing trainings. A randomized controlled trial conducted on 207 hospital-based nurses in Athens and Thessaloniki, Greece, to evaluate the impact of an educational program on their knowledge of disaster response found that the program was effective. The knowledge and self-confidence of the nurses markedly improved. However, the program did not affect their behavioral intentions (Pesiridis et al. 2015). Consequently, the study shows the limits of interventions while affirming the need to improve knowledge outcomes.

The teaching and learning of climate change knowledge in both formal and informal educational settings is pivotal for transforming behaviors and strengthening resilience (Petal and Izadkhah 2008; Foss and Ko 2019; Reid 2019). Implementing disaster risk reduction educational frameworks in schools

has been an effective way to build on youths' personal experiences during disasters, unpacking perceptions, and developing evidence-informed knowledge about the effects of climate change. The International Federation of Red Cross and Red Crescent Societies has invested in educating communities using formalized curricula, along with participatory learning and informal community-based solution building activities (International Federation of Red Cross and Red Crescent Societies 2011). Quasi-experimental studies in Zimbabwe and Taiwan demonstrate that disaster education programming in curricula for young people—university students, in the case of Taiwan—was an effective way to increase risk perception and promote pro-environmental attitudes (Muzenda-Mudavanhu et al. 2016; Yu et al. 2020). Both studies found the youth to be adept in climate change solutions and spread this awareness to the public. However, the Zimbabwe study found that even with robust curricula, students might lack coping capacity if a disaster occurred. In addition, climate change educators need more training (Rambau et al. 2012), and more local governments need to incorporate disaster risk reduction campaigns into schools (Foss and Ko 2019).

Governments play a key role in ensuring that disaster risk reduction information is being transmitted to the public and shared in a manner that is consistent, credible, and translatable. Whether regional, national, or local, governments can be strong advocates for climate change education and tools to reduce disaster risk. A national strategy or campaigns implemented through the government are needed for the systematic promotion of awareness—reducing damages and loss after a disaster—and for increased household buy-in for pro-environmental policies (Paci-Green and Petal 2009; Frumkin and McMichael 2008). But to reduce population exposure, government accountability must be assured. And as shown in a study of noncommunicable diseases (Lake and Fenner 2019), the population's response capacity is enhanced when the government offers hazard mitigation language and policies that include multiple interventions and are iterative.

Governments extend their roles in disaster risk reduction even further when they invest in national platforms and technologies that are translatable for at-risk populations. More training and support activities can strengthen governments' capacities to manage the impact of catastrophes and offer feasible risk transfer solutions. As a publication from the Asian Development Bank says, capacity building in the form of training on community-based planning, resilience building, gender, leadership, and livelihood development can help a government increase education and awareness (Asian Development Bank Community Resilience Partnership Program 2019). Technologies are available to help improve risk awareness in the policy planning process. Some are tailored to reducing risk to a specific weather-related event, such as coastal hazards (Klein et al. 2001), while others acknowledge the importance of “soft” technologies such as capacity building and training and “hard” technologies

such as infrastructure and engineered solutions (Klein et al. 2005; Klein and Tol 1997). In Italy, the government funded the #italiasicura web platform to identify hazard mapping for flood and landslide risk (Bignami 2018). The platform can be shared on any media, including social media, and is accessible to people with different technological competencies. From web analytics, the government found that the tool could monitor social awareness and a community's ability to perceive risk in a measurable way that allowed for community comparisons. Awareness building also involved highlighting community engaged methods for disaster risk reduction, which was feasible with the high level of citizen buy-in and use of the tool. The user's capacity and ability to understand the information that was shared are key to the effectiveness of awareness activities (Palutikof et al. 2019).

Two experimental studies, one in Bangladesh (Hossain et al. 2015) and the other in the United States (Goldberg et al. 2019), explored how technology tools—including audio messages, SMS messaging, videos, and images—are used to spread awareness of disaster risk. The Ministry of Education in Bangladesh funded a study to use multiple media under a mobile coach-based intervention to increase parents' knowledge and awareness of the risks of childhood drowning. The results have not been published, but the goal is that with more touchpoints for information, parents will gain awareness of factors and situations that could lead a child to drown, which in Asia is the third leading cause of death for children from birth to age 4. The US study focused on one technology format, video messaging, and found that people had better perceptions of their risk when they watched videos, compared with when they only read the video's transcript. Similar studies have shown the effectiveness of video messaging in the Philippines (Haynes and Tanner 2015), and the Virtual Human Interaction Lab at Stanford University simulated the impact of carbon emissions on ocean acidification to encourage behavior change (Williamson et al. 2018). These studies show that once there is technology capacity, even in a simple form such as SMS messaging, disaster risk management and climate change education can spread to larger population groups with the flexibility to be tailored and specific.

General risk awareness at the national and local level is essential for encouraging pro-environmental behaviors and reducing disaster risk. However, it is still challenging to measure when action is mobilized because of these activities, and more experimental research is needed (Save the Children 2015; Bradley et al. 2014).

## **Targeted Outreach and Engagement**

We identified 16 studies, primarily scholarly exploratory literature, that unpack considerations for using EWS in resilience building. Some studies address EWS use at the national level and show that they

strengthen local government capacity and deliver a positive return on investment nationally. A few studies discuss the value of using EWS at the community level, particularly for sharing information among vulnerable households (i.e., older adults, people who are disabled, and families with low incomes). One study includes a systematic review of 31 documents (half peer-reviewed evidence) on how communities use EWS, mostly identifying lessons learned from low- and middle-income countries. To be most effective, the messaging source must be timely, credible, responsible, and flexible and use an appropriate medium. However, communicating about resilience planning with communities that have never experienced that type or level of risk can be challenging.

EWS strengthen capacity to predict hazards for large populations in a timely and accurate manner and can reach vulnerable communities through creative channels (Rogers and Tsirkunov 2011; International Federation of Red Cross and Red Crescent Societies 2019; Mileti and Peek 2002; Mileti and Fitzpatrick 1993). EWS could be used as more than a mechanism for sharing hazard risk information; they could also be used to catalyze action before a disaster even occurs. Upgrading these systems is costly—an estimated \$4 billion in developing countries—which might debilitate governments with limited resources. But the long-term benefits for the population can be tremendous, ranging from \$4 to \$36 billion (International Federation of Red Cross and Red Crescent Societies 2019). EWS on their own are not effective, however; they require streamlined communication networks, and the population at risk must perceive them as credible messaging formats. EWS have further reach when they are packaged for the media (Mileti and Peek 2002), oriented toward the audience, and aligned with key next steps. Implementing a comprehensive system with triaged warnings may not be possible given varying capacities and the urgency of disaster risk management. So, to ensure that EWS have maximum benefit and best serve the population's needs, the message must be coordinated and consistent across government agencies, particularly when each agency may have a joint responsibility but different mandates for support (Rogers and Tsirkunov 2011; Mileti and Sorensen 1990).

Recognizing the importance of managing disaster vulnerability and risk exposure, global organizations have made significant investments in mechanisms to promote early warning and preparedness activities. The World Bank and the United Nations Development Program released best practices in accordance with the 2005 Hyogo Framework for Action on how EWS can be better used to identify, reduce, and transfer risk (Rogers and Tsirkunov 2011; Brazzola and Helander 2018). They highlight the importance of people-centered warning systems that have a multihazard approach and build on institutional partnerships (Jayasir 2018). For instance, during a July 2006 heat wave in France, the government implemented a national plan that rolled out information through several media and targeted vulnerable populations such as older adults and people with medical conditions. The impact of

that heat wave was significantly less than what the country experienced during a heat wave that occurred in 1976 (Rogers and Tsirkunov 2011). Investments have also been made in forecast-based financing, to reduce humanitarian response costs and equip countries to become more resilient (International Federation of Red Cross and Red Crescent Societies 2019).

Regardless of size and capacity, most countries have invested in national EWS (Rogers and Tsirkunov 2011; Garcia and Fearnley 2012; Torres and Puig 2012), including standardized policies and protocols that strengthen the systems (Jayasir 2018). They often account for varying levels of urgency and the vulnerabilities of different populations. The national system implemented in Cuba, for example, can predict and share disaster information in real time while modeling risk scenarios and preparedness plans by population and type of disaster (Torres and Puig 2012). An important enabling factor of the system in Cuba has been the legal framework that guides national coordination and channels information to communities that face the greatest risk.

Climate change can pose a significant threat to vulnerable communities in addition to the general threat people face. To combat this, EWS have been developed on the community level to consider the local context. Early action is paramount for reducing risk, and when local leaders are at the helm of awareness activities, they reinforce national awareness building by tailoring messaging for specific populations and from trusted sources. However, in Nepal, the community response capacity building was not linked to the national EWS, and without this integration through institutional support (district, provincial, or national government), it was less effective (Sufri et al. 2020). When aligned with national efforts, peer-led, nontechnical decisions are considered more credible, and when consistent and repeated, they encourage greater resilience, particularly for groups that rely less on the news, scientific data, or other channels for trusted information (Macherera and Chimbari 2016; International Federation of Red Cross and Red Crescent Societies 2019; Mileti and O'Brien 1992; Cyr 2005).

Community EWS such as evacuation drills, risk mapping, training of informal masons and builders on resilience infrastructure practices, and flood monitoring, among other techniques, have been valuable people-centered activities for raising awareness. Community members can catalyze resilience building from lived experiences and information sharing. For example, after the 1995 earthquake in Kobe, Japan, advocates in the San Francisco Bay Area and Seattle saw greater risk awareness and a keenness for hazard education (Mileti and Peek 2002). In addition, schools have used emergency drills to test individual and organizational capacity to respond to disasters, and this mechanism has played a crucial role in school disaster risk reduction planning (Johnson, Towers, and Petal 2018).

When effective, EWS can move the needle on behavior change by mobilizing a country, region, or local community. This requires people-centered training, efficient allocation of funds, and capitalizing on perceptions and past experiences. A group's perception of danger can reinforce the need for messaging that is neither ambiguous nor subjective; moreover, this might look different for pre- versus post-disaster warnings (Lorenzoni et al. 2005; Mileti and Fitzpatrick 1993). Developing EWS can be challenging when people have not experienced a similar event and may not have the language, resources, or capacity to respond (Mileti and Peek 2002; Mileti and O'Brien 1992; Lorenzoni et al. 2005). But developing systems that are dynamic and flexible—such as color coding norms for hazards, with red as dangerous and green as safe, or using pictures as a communication tool to reach more people—encourages more equitable, creative use of EWS for disaster risk reduction.

## Local Knowledge

The researchers identified nine recent studies that explore traditional knowledge generation processes as an approach to resilience building. All studies highlight that local, indigenous knowledge can build community capacity to manage climate change risks. Three studies highlight the importance of credible local messengers. One experimental study in Latin America and the Caribbean found that more flood and tsunami hazard risk awareness came from generational knowledge than from expert knowledge sharing. In the findings, many studies discuss that participatory tools, such as workshops and trainings, can improve understanding.

Traditional and local knowledge systems can be the most appropriate way of building community resilience. Local knowledge can help educate and mobilize people toward pro-environmental behaviors and strengthen their understanding of the effects of climate change better than expert information can (Petal et al. 2008; Paul et al. 2019). Studies have found that the capacity of local communities to predict weather conditions is strong (Adger and Kelly 1999; Moser and Dilling 2004) and that the awareness level from generational knowledge is high (Cubelos et al. 2019; Paul et al. 2019). In northern Chile's Atacama Desert, planners were aware of the high fluvial flooding and tsunami risk faced by the town of Chañaral. Through community conversations, however, they learned about an additional flood risk, from high intensity rain, that had not been extrapolated from the community mapping and hazard simulations (Cubelos et al. 2019). Insights from indigenous knowledge that has passed through generations of the town's families revealed the coping processes and resilience measures the population had been taking.

Passing down local knowledge, either generationally or across specific groups, requires credible local messengers whom people trust. Economists who can quantify potential damage, social scientists who understand cognitive mechanisms that influence human behavior, and technical experts who can help implement feasible solutions can benefit from partnering with credible messengers to empower local community members (Moser and Dilling 2004; Adger and Kelly 1999). Citizen advisory committees can be a great tool for deploying credible local messengers to increase public engagement in environmental policy and management decisions. Studies have found varied evidence demonstrating the influence of these committees on policy outcomes, however; sometimes, they have significant policy impacts, while other times, their influence is limited (Lynn and Busenberg 1995). Regardless, having a local voice that the community trusts in disaster resilience planning can support tools and approaches that strengthen the community's coping capacity (Cubelos et al. 2019).

Yet even if disaster risk planning and management uses local knowledge, an enabling political environment is necessary to encourage awareness. Local vulnerability often comes from a community or resident's limited ability to access appropriate resources to become resilient to hazards (Adger and Kelly 1999). Without policies that encourage awareness of risk, building community-level resilience can be difficult. A study found that the high political engagement in climate change issues (e.g., contacting political representative, participating in climate change activism) has led Latinx Americans to have stronger risk perceptions and more pro-climate tendencies than white Americans (Ballew et al. 2019). Building social norms of awareness in tandem with strong political will helps manifest climate change awareness and thus improved coping capacity.

Typically, strategic thinking and long-term risk reduction are the responsibility of national and regional planners and policymakers. Leaning on local knowledge involves a shift from top down information sharing to decentralized, bottom-up, participatory, community-based approaches that use citizen science, traditional understandings, and technology—such as the internet, social media, and smartphones—to create accurate, real-time information on disaster risk (Paul et al. 2019). As such, participatory tools, such as community workshops and training, can bolster local knowledge and improve risk awareness. Researchers in the Okanagan Basin in Canada's British Columbia saw the benefits of a series of one-day workshops on the implications of climate change on water resource management (Langsdale et al. 2009). The effectiveness of workshops can be limited, however, if community participation wanes and members do not feel ownership of the process. Mainstreaming climate change communication should happen alongside capacity building of local disaster risk management personnel (Prabhakar et al. 2009; Ballew et al. 2019). This allows communities, which may not trust or adhere to information from scientists or national-level campaigns, to better prepare to



make informed decisions if a hazard occurs. Furthermore, when equipped with the appropriate knowledge and tools, communities can expand from being implementers of community-based risk management to also being innovators of pro-environmental solutions (Cubelos et al. 2019).

## Arts and Culture

We found 11 recent studies, of varying levels of rigor, that highlight how the arts can raise awareness about climate change. Five studies acknowledge that stimulating behavior change requires creativity and personal engagement. Others delve into examples of how compelling and informative messaging on resilience was built through specific media or how a disaster was used as the catalyst for shared learning to be expressed in a creative way. A few studies gathered evidence using quasi-experimental methods, but for the most part, effectiveness was determined with a more subjective lens, one that focuses on the promise of the approach. Regardless, the evidence on arts and culture highlights opportunities for education and awareness raising, not only for community members but for policymakers and practitioners, particularly as they explore options for innovative messaging.

Personal engagement and trust building are essential for both educating people about the effects of climate change and encouraging pro-environmental behavior change. The ability of the arts—for example, storytelling, visual arts, cultural productions (i.e., plays, musicals, dances, movies)—to connect people has tremendous value (Young and Cao 2019; Sommer and Klöckner 2019; Schaefer and Waters 2016). Climate change education and awareness increasingly comes from a combination of activist art modalities, environmental science, and psychology and behavioral methods. They can serve as another avenue for capacity building, especially among intergenerational groups that require multidisciplinary media (Schaefer and Waters 2016). Traditional approaches that use messaging around science-based information and data have been less effective in describing the importance of public action, communicating the urgency of addressing environmental problems, and inspiring action at the individual level (Dahlberg, Hoffman, and Maurakis 2017; Doll and Wright 2019).

Over the past 10 years, activist art has become an important strategy for educating people and inspiring them to address social issues such as climate change through emotional triggering (Sommer and Klöckner 2019). Activist art uses cognitive mechanisms that spur personal connections to the message. Satisfaction surveys conducted at large art installations and exhibits have found that viewers have strong emotional responses—including sadness, helplessness, and anger—to the implications of climate change (Sommer et al. 2019), and this in turn mobilizes cognitive awareness in the viewers, who have learned something new and resolved to adopt more pro-environmental behaviors (Sommer and

Klößner 2019; Dahlberg, Hoffman, and Maurakis 2017). The psychological activation of artwork is still being explored as a tool for encouraging awareness among broader audiences, but these early findings, which point to personal responsibility in contributing to the resilience narrative, offer promise (Sommer et al. 2019).

Art and theater activities have been particularly useful for sharing information and building awareness among vulnerable communities. In several South African communities, storytelling and video techniques were used in a workshop style to share reflections on flood and drought resilience. The communities were more receptive to this format of narrative sharing than to visuals, and this helped narrow the intergenerational knowledge gap (Loon et al. 2019). In addition to raising local awareness, the videos were a catalyst for conversations with policymakers. Similarly, the Pan-participatory Assessment and Governance of Earthquake Risks in the Ordos Area in northern China explored how earthquake resilience scenarios combined scientific evidence with practical knowledge (Young and Cao 2019). Disseminating knowledge with storytelling and illustrations educated the public as well as local government agencies.

Finally, some studies aim to better understand how activist artists choose to reflect climate change effects and raise community concern. Understanding how the artistic community expresses its perspective on climate change is essential for examining how the art evokes emotion and changes the behavior of viewers (Doll and Wright 2019). In some cases, artists' experiences have been used to expand understanding of disaster risk. For instance, to raise awareness of improved flood management, children in the United Kingdom shared their experiences from the 2013–14 winter floods in a performance. The actors communicated how they felt during the floods and what they would like to see done differently for future disaster events (Williams et al. 2017). Globally, programs have tailored funding and capacity building for artists to produce meaningful, human-centered cultural works that encourage education and awareness (Hand and Fransz 2019). ArtPlace America has been an important driver of these activities in the US, and the motivations of creative placemaking are extending to countries looking to empower artists to facilitate discussions and develop solutions for the public.

## The Opportunity

Awareness of individual, institutional, and community-wide risks from climate change's effects as well as other environmental hazards and social stressors is still minimal at best, though increasing. New techniques must be developed, and proven techniques deployed for a wider population. Education and awareness campaigns are critical for building public knowledge of climate crises and individual risk, and

strengthening efforts to improve resilience (Klein et al. 2000). Moreover, targeting awareness campaigns can help balance social disparities, such as gender inequality, poverty, political power imbalances, and the historical disregard for local and traditional knowledge (IPCC 2014). When done appropriately, there are several opportunities for education and awareness campaigns to frame climate change narratives in ways that reduce disaster risk regionally, nationally, and for the most vulnerable populations.

General risk awareness in the form of government-led campaigns, web-based platforms, curriculums in school and other strategies, improve preparedness and response capacity, and are more likely to lead to behavior change and self-efficacy. Awareness in the form of “hot spot” location targeted outreach and engagement techniques can double down on general risk awareness efforts by allocating resources into EWS and other alert platforms. These tend to offer large-scale knowledge dissemination, which can not only be far reaching but deploy communication rapidly. To both ends, the following strategies could be explored with the appropriate governments, researchers, and civil-sector organizations:

- expanding alert systems in high-vulnerability, low-capacity jurisdictions, such as in developing contexts, potentially through resourcing and testing new technologies such as mobile phone emergency systems and related applications such as the European “Extrema” heat warning systems, Red Cross apps, and mobile phone provider alerts
- coordinating the expansion of public emergency drills and awareness-building events, such as California’s “Great Shake Out”
- supporting behavioral research on messaging, media, and resulting actions for both short-term (e.g., alerts) and long-term (climate risks and hazard exposures) communications
- resourcing current organizations that are researching and experimenting with risk communications, such as the various climate communications and media efforts

While recognizing the unpredictability of disasters, there is a growing shift to acknowledge the importance of sustained indigenous information through the sharing of local knowledge. This type of outreach can be tailored for specific populations, and dissipate disaster knowledge gaps and build community capacity to manage climate change risks. The shift in techniques to better address resilience building has also led to the use of more unconventional means for increasing awareness. Potential opportunities to partner with local grassroots groups include the following:

- using local organizations and grassroots community groups to provide critical communications about risks as identified from credible scientific sources; expand conversations about critical shocks, such as climate change effects; and use these to gather collective solutions to be integrated in formal public-sector planning and scientific research such as those supported by the Climate Justice Resilience Fund and the Slum/Shack Dwellers International
- developing a network of such organizations to ensure their sharing of best practices for mobilizing grassroots knowledge and their political capacity
- advocating among multilateral and philanthropic funders to support further grassroots organizing, particularly in “frontline” communities

The arts and cultural productions are increasingly seen as platforms for sharing information on disaster risk, particularly for children, who can be highly vulnerable. The following are examples of strategies that provide a new and important channel for climate change education and awareness of risks:

- developing creative, instructional modules for children with curricular developers to raise awareness and familiarity about key risks, such as those associated with climate change
- publicizing artistic productions related to risks
- encouraging international and national arts funders to prioritize resilience-aware cultural productions, such as UNESCO
- convening key stakeholders to address the risk to historical and cultural patrimony in high-vulnerability, low-resource nations as a vehicle for expanding public awareness and participation in resilience actions

According to experts interviewed for this study, key priorities for this action area include strengthening citizens’ voices and creating feedback mechanisms—factors that can contribute to the iterative learning that climate adaptation requires. Populations worst affected by climate-induced disasters build knowledge in the processes of managing such risks, but, where feedback loops are lacking, such vital indigenous information is not accounted for in resilience efforts. Therefore, per one respondent, there is a need to boost citizen involvement in decisionmaking processes in the resilience space, especially in urban areas.

While increased community engagement could improve the quality of solutions, more work is needed to enhance the effectiveness of public messaging in shaping people’s risk perception and responses, even when risk information is imperfect. According to a few respondents, due to additional

factors such as lack of resources, it is often the case that access to risk information does not always lead people to take early action that builds coping capacity (e.g., evacuations). Ultimately, these practitioner perspectives call for considerations of how the local financing environment promotes or undermines the effectiveness of education and awareness efforts.

## Unit of Intervention

Public awareness and education campaigns are targeted to individuals, whether independently or grouped in demographic collectives or geographic communities. This detailed unit of intervention allows for direct and easy calculation of opportunities' outputs (such as individuals who have downloaded mobile apps or students who are participating in training).

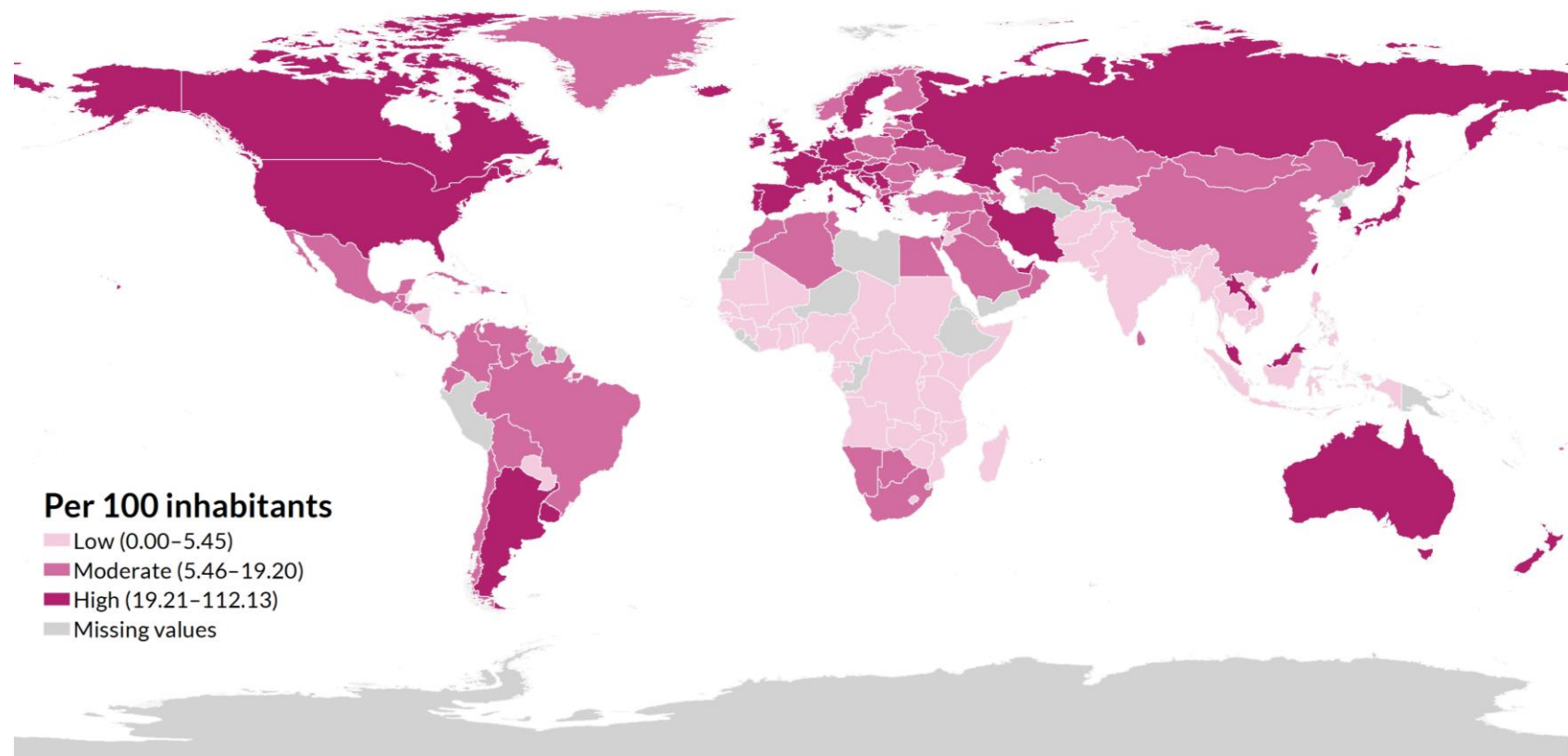
## Scale of Intervention

Consequently, this action area's solution also has the widest potential scale. However, the goal of educating individuals about their risks and potential behavior changes and actions requires intensive planning, message tailoring, and marketing to the respective groups. Articulating a feasible point of entry for those kinds of physical interventions faces the challenge of diversity of places and context. For social programming involving households and individuals, the challenge of replicability is magnified by several orders of magnitude. Individual opportunities, especially in pilot form, are therefore likely to only reach a limited population.

However, there is an opportunity to utilize increasingly ubiquitous information and communications technologies to better reach a wider audience. With this potential, the reach of technologies should be considered. The distribution of nations' rates for telephone land lines (figure 21), mobile phones (figure 22), and internet broadband (figure 23) reflects overall development rates. Potent entry points for growth in these opportunities may be in high-exposure regions of high- to moderate-access nations so that messages and technologies could be tested prior to further expansion.

FIGURE 21

Fixed Telephones per 100 Inhabitants, 2018

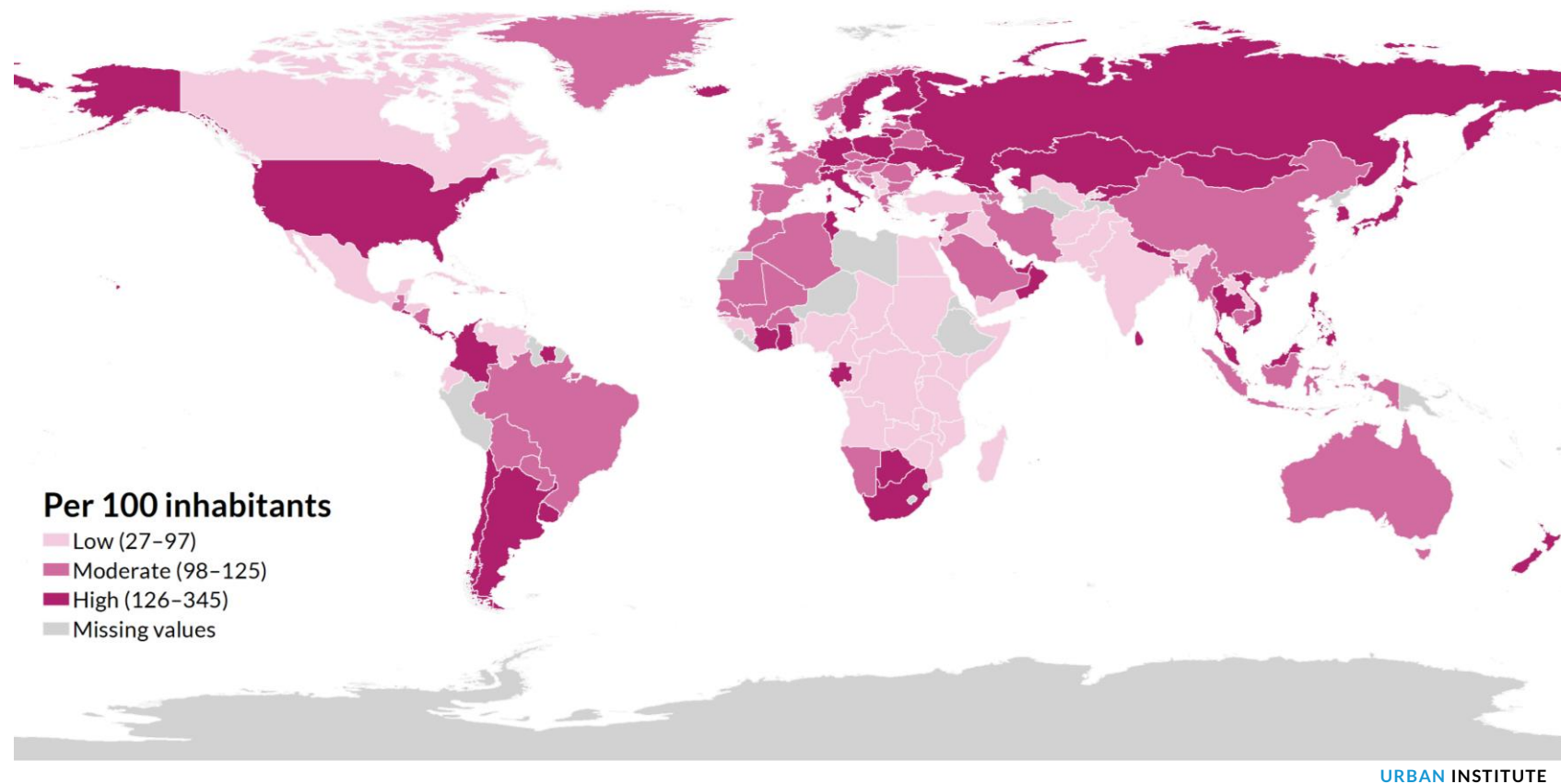


URBAN INSTITUTE

Source: “Fixed-Telephone Subscriptions,” International Telecommunication Union, accessed April 1, 2020, <https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx>.

FIGURE 22

Mobile Telephones per 100 Inhabitants, 2018

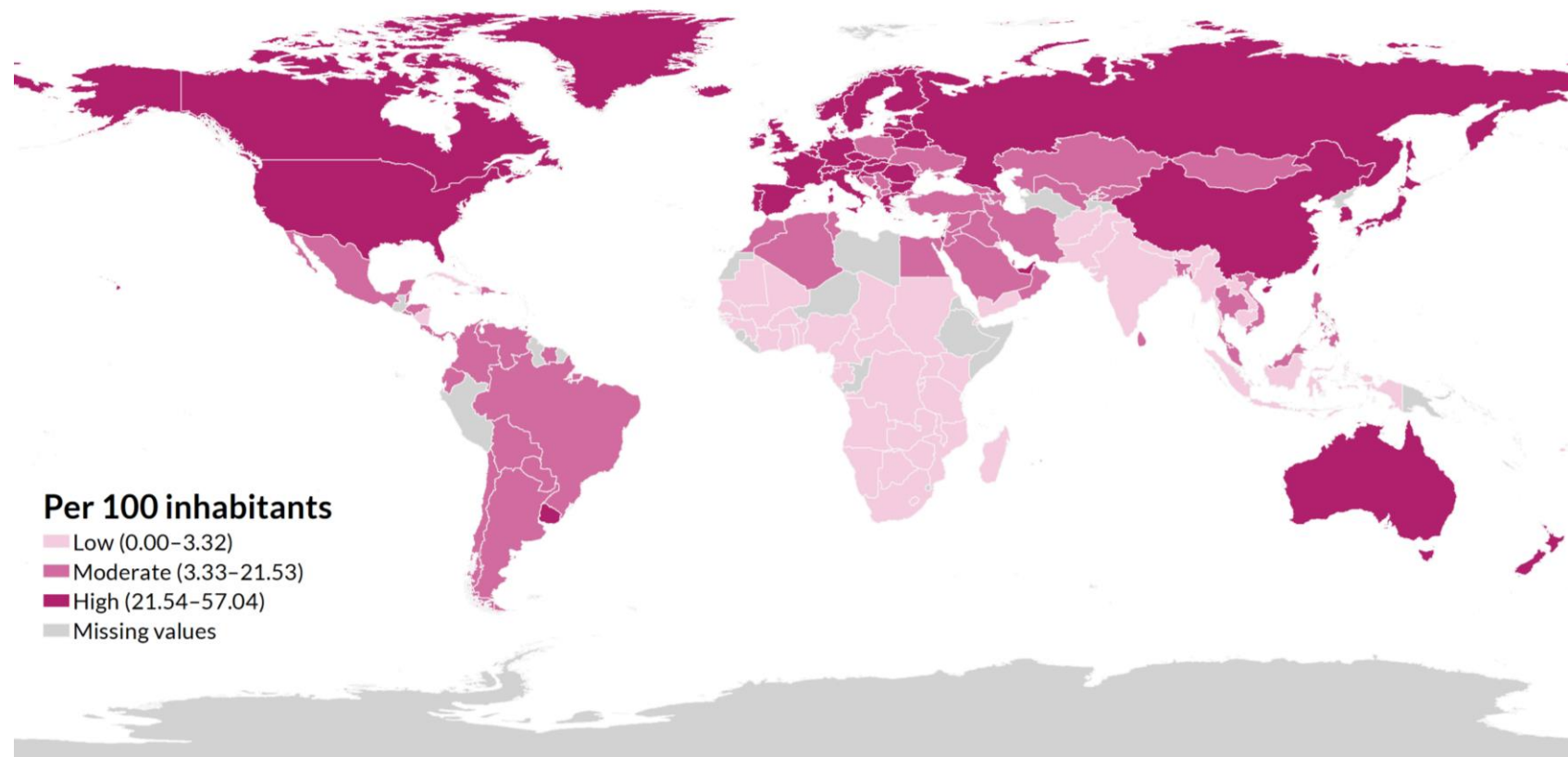


Source: “Mobile-Cellular Subscriptions,” International Telecommunication Union, accessed April 1, 2020, <https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx>.



FIGURE 23

Broadband Internet Access per 100 Inhabitants, 2018



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Source: “Fixed-Broadband Subscriptions,” International Telecommunication Union, accessed April 1, 2020, <https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx>.



## Summary

The four categories defined in this action area reflect two themes: the ongoing challenge of providing information to all members of communities regardless of background and education as represented through decades of emergency alert testing and refinement, and the very recent growth in public awareness campaigns (particularly around climate change) that seek to both convey critical information creatively and compellingly about risks and shocks while also receiving including local communities' knowledge and concerns in forming shared solutions. There is a stronger and more robust evidence base for the former themes, though this stems largely from its history of implementation, evaluation, and programming. Preliminary evidence for the latter opportunity categories poses a wide potential room for growth, though their implementation will be costly, drawn out, and typically place- and community-specific.

Though the objective of all these efforts is to affect individuals, the potential for these efforts' achieving that objective is mediated by their resourcing and reception from

- the national or subnational governments that typically control emergency management and environmental policies and the messaging around both;
- the multilaterals, governments, and charitable investors in one-way (including educational curricula and alert systems) and two-way (grassroots inclusion and cultural productions) communications; and
- the creative private developers—along with the marketers—of software, visualization, and prose that would be needed.

Consequently, a significant amount of resources and knowledge would be needed to communicate even a subset of risk information across the range of contexts, demographics, and media. Despite the potential challenges, improving education and awareness of both short- and long-term risks is a critical component for building resilience.

# Food Security

The last action area synthesizes a body of scholarship and international development practice focused on the changes to agriculture, food consumption, and nutrition that will likely occur as a result of shocks such as climate changes effects and on the potential strategies for adapting to them. This emergent category of activities is included because of the strength of recommendations by both researchers and resilience development practitioners that appeal directly to rural and agricultural development resilience as well as urban food security. Lack of food has been cited as a critical challenge after disasters, for example (UNISDR 2014).

## The Challenge

Climate change will place increased stress on all aspects of food security, including production, access, and nutrition (IPCC 2014). Increasing resilience in terms of food security necessitates growth in these areas to feed a rising population in a warming world (IPCC 2014). Changes in climate will affect seasonality and water supply, which will in turn alter crop yields and strain agricultural systems (IPCC 2014). All plant, livestock, and fishery populations will experience the effects of climate change (IPCC 2014). While there may be short term gains for some organisms and regions, most long-term consequences will be adverse (IPCC 2014). Challenges to food security in a changing climate include soil depletion, decreased water supply, deforestation, fisheries depletion, limited land space, biodiversity loss, nutrient poor staple crops, natural disasters and extreme weather events, and food production as viable and reliable income source (FAO 2008; IPCC 2014). There is growing consensus on and use of effective strategies to combat these problems (FAO 2018a). However, challenges to implementation stem largely from lack of information, material resources, or incentive to adapt (Kopittke et al. 2019).

Unequal access to food has remained a core component of food security throughout changes fueled by population growth and exploitation of natural resources. Food security affects populations across the globe, though it manifests differently in rural and urban areas, as well as richer and poorer geographies (IPCC 2014). With climate risks, food security contains additional complexities associated with human and ecosystem health. There is a need to alleviate hunger and malnutrition in some areas, while other areas may be experiencing health risks associated with overconsumption (de Boer and Aiking 2011; FAO 2019a). Many techniques for adapting to a changing climate and higher demands on food systems have been explored and tested, but challenges remain in deploying solutions at large scales to meet yield demand.

All dimensions of food security—food availability (i.e., production and trade), stability of food supplies, access to food, and food utilization will likely be affected by climate change (FAO 2008a). There is a growing list of methods that farmers are using to combat observed climate changes including improving cultivar tolerance to high temperatures, breeding drought tolerant crop varieties, and changing growing patterns. The effectiveness of these adaptations will vary depending on whether the adaptation is intended for the current climate or designed to meet future climate scenarios. In some cases, these adaptations are most effective in combination (IPCC 2014). Research notes several barriers to implementation, including: lack of adaptive capacity, institutional inertia, insufficient fertile land, inadequate information of the risks and benefits of the adaptation options, infrastructure, and cultural acceptability.

Local adaptation choices, however, are emerging in both rural and urban contexts for the slow-onset kinds of effects observed from climate change. A very wide variety of activities have been tested and identified in this area, ranging from indigenous farming techniques to cutting-edge genetic modifications to plant species. Because of the place-based nature of many of these interventions, the researchers have loosely categorized these strategies into the following four potential areas:

- **Agricultural research and development** for resistant seed and planting. Without considering adaptation strategies, the future impacts of climate change, specifically high temperatures, will reduce the quality and yield of crops around the world (Karimi et al. 2018; Shimono et al. 2010). Improving cultivar tolerance to high temperatures is frequently noted in literature and identified for almost all crops and environments (Shimono et al. 2010). However, certain cultivars can take years to become resistant (Ziska et al. 2012). Various options exist for supporting research on climate tolerant crops and livestock and on agrobiodiversity through genetics (Campbell et al. 2008; CCCD 2009; Easterling et al. 2007; FAO 2007, 2010; World Bank 2009).
- Providing a safety net for individuals and communities whose **livelihoods are dependent on agriculture**. Using the same analyses conducted for the social protections described in the action area of direct financial services, a wide number of cash assistance and farmer savings strategies are needed.
- **Agricultural insurance and finance**. As with other forms of insurance, crop and livestock insurance aims to provide recipients with preventive options for combating disasters (CCCD 2009; FAO 2007; UNISDR 2009; World Bank 2009). Research centers around three types of insurance strategies, sometimes in combination: community-based insurance, federally funded crop insurance, and private-public risk sharing.

Community-based crop insurance can take the form of microinsurance, as shown in the case of three Mongolian provinces. Linnerooth (2009) details the index-based livestock insurance program that has a layered system of responsibility and payment. The low-income farmers retain small losses, while the next layer of losses is transferred to private insurers, with the final layer of risk absorbed by taxpayers. In Malawi, a similar structure as Mongolia exists, but its index-based system aims to be more preventive than responsive to disasters, as it has precipitation-measuring weather systems that, depending on your location, affect the premiums that would be offered (Linnerooth 2009).

The literature on federal crop insurance programs shows that these programs are more of a private-public partnership. For instance, the US Department of Agriculture established the insurance premiums and then subsidizes private insurers and a portion that is meant to be paid by farmers (O'Hara 2012a). However, with federal programs, there can be a lack of diversification in the types of crops and livestock covered under the insurance plan, which makes farmers less likely to diversify their crops and insurance companies less likely to insure regions where specific farming practices are not occurring (O'Hara 2012b).

- **Resource stewardship.** Disseminating and enforcing proper and scientifically updated methods for managing crops (such as crop diversification), soils, fisheries, forests, water for irrigation, and agricultural wastes are underlying challenges.

For crops, for example, opportunities exist to expand crop switching and changing planting seasons. Higher temperatures can also lead to changes in growing seasons, whether that means extended cooler periods or drought. Researchers have identified the changing of growing patterns in crops as a viable option in combating climate change (Shimono et al 2010). Dry sowing in certain regions has been effective, although it is a risky practice because of the potential danger of germination beginning earlier with a small amount of rainfall and then stopping (Passioura and Angus 2010). Other techniques include seedling transplanting and seed priming, although a wide variety of techniques can fall under this agricultural adaptation pool (Butler and Oluoch-Kosura 2006; Butt et al. 2005; CCCD 2009; Davis 2004; FAO 2006, 2008a; Howden et al. 2007; McCarl 2007; World Bank 2009).

Planting and soil maintenance practices include urban farming, efficient irrigation and water conservation, changes to livestock and fishing practices, and food storage and preservation innovations. A wide range of food security adaptation actions are under this umbrella, such as training for sustainable land and water management, efficient water use and storage, agroforestry, protection shelters for crop and livestock diversification, improved supply of

climate stress tolerant seeds, and integrated pest and crop disease management (Arnell 2004; Branco et al. 2005; Campbell et al. 2008; Easterling et al. 2007; FAO 2008a, 2009; Howden et al. 2007; McGray et al. 2007; Neufeldt et al. 2009; SCBD 2009; UNISDR 2009; World Bank 2009). The lack of robust delivery mechanisms for disseminating these potential actions and gaps in local capacity to integrate them are both major challenges in this sector.

- **Nutrition.** The ongoing reliance on and expansion of animal protein-heavy diets are creating problems for individuals' health as well as that of the planet. Challenges including malnutrition are further complicated by environmental shocks. The lack of tools to redress the demand for less nutritious food and its effect on the supply and suppliers present numerous possible imperatives, including greater production of and improved marketing/communication of plant-based protein sources; closing geographical crop yield gaps (specifically between poorer and wealthier areas); increased production of crops for human, rather than animal, consumption; greater consumption of fruits and vegetables (particularly in developed countries); and increased health system investment in food systems.

## The Evidence

Contemporary literature on the needs and solutions for long-term food security covers an array of themes, many of which are addressed through a small network of agricultural and food aid organizations on a global scale. Despite the diversity of topics, Urban researchers explored the evidence base in the five following categories.

### Agricultural Research and Development

We identified 30 recent monographs—exploratory studies, case studies, and advocacy papers published in scientific scholarly journals or by multilateral institutions like the Food and Agriculture Organization of the United Nations (FAO)—that present information on the potential for broadly adapting agricultural systems to climate changes. Agricultural research and development is a rich field with myriad information on the broader vulnerabilities of agriculture to climate change, as well as strategies related to crop yield, technology, biodiversity, disease management, livestock, and agricultural markets and producers.

Specific strategies include increasing livestock and pasture productivity; improving crop breeding and yields; changing planting times and frequency; protecting ecosystem services; limiting cropland

expansion to areas with low environmental opportunity costs; implementing reforestation; conserving peatland; improving technology for enteric fermentation; improving manure and feed management; increasing use of emissions-reducing crop management and varieties; developing cultivars that are resistant to heat, disease, drought and other stressors; using improved cultivars; adapting growing patterns and seasons; expanding cropland; connecting farmers to extension services; improving reproductive capacity of livestock (especially cows); reducing input (i.e., seed, water, and fertilizer) requirements; increasing use of C3 agricultural crops; promoting efficiency of seed systems; increasing agroforestry and pastoral systems; sharing knowledge about climate smart agriculture; developing nuclear and isotopic techniques for climate adaptation and resilience; and developing a global early warning system for plant pests and diseases. Currently developed models and tools include the Global Livestock Environmental Assessment Model (see FAO 2019b), the Ex-Ante Carbon-balance Tool,<sup>1</sup> the Agricultural Stress Index System (FAO 2019c), AquaCrop,<sup>2</sup> the Information Network on Post-Harvest Operations.<sup>3</sup> Some of these strategies may overlap with more specific areas of intervention outlined in subsequent sections, such as crop diversification or planting and soil maintenance practices.

Much of the current work in agricultural research and development as it relates to food security and climate change coalesces around climate smart strategies. Climate smart agriculture includes practices that promote soil and nutrient management, efficient water harvesting and irrigation systems, pest and disease control, conservation of genetic resources, and biodiversity and increased ecosystem services like pollination, waste decomposition, and nutrient cycle regulation (FAO 2010). More specific examples include developing heat- and other stress-resistant cultivars, altering growing patterns (e.g., planting and harvesting times), expanding cropland, and preserving and expanding biodiversity (Butt et al. 2005; Chakraborty and Newton 2011; Dhankher and Foyer 2018). Some crops may benefit from increased carbon in the atmosphere (Easterling and Apps 2005), but it is important to note that simultaneous effects of climate change such as drought or flooding may have co-occurring adverse effects (FAO 2010).

Animal agriculture is another aspect of agricultural research and development that warrants attention. If current trends in global development and their implications on diets continue, the demand for beef and milk will grow as nations expand their wealth and the amount of meat and dairy in their diets (Davis and White 2020; FAO 2019a). Livestock are also vulnerable to any cropping changes that result from climate change and affect their food supply, particularly in rural, less developed areas (Ericksen et al. 2011). Given the strain that livestock places on water and land supply, developing reproductive technologies for cows and other grazing mammals like artificial insemination, embryo transfer, and in vitro embryo production, as well as genetic selection and nutrition management, can

help increase reproductive productivity while reducing the number of animals (Davis and White 2020; FAO 2019a). Additional strategies for livestock adaptation to and mitigation of climate change include expansion of agropastoral systems, higher efficiency feed growing systems, strategic placement of animal production near feed production and/or markets, genetic research, recycling of manure and slaughterhouse waste as fertilizer or renewable energy power, general expansion of solar and wind energy on farms, and livestock subsidies for reduced emission production (Drieux et al. 2019; FAO 2019a).

Although there will always be a need for agricultural research, a finite set of activities that will allow climate smart strategies could be implemented globally. Actions that promote cross-stakeholder interaction are one way to ensure that strategies from agricultural research related to climate change and food security can become a reality (FAO 2010). Possible activities include increasing the number of staff members working in between agricultural research and development, producers, and policy makers—people who can communicate between agricultural producers, climate scientists, and policymakers to ensure that information flowing between these groups is adequate and accurate to increase proper and efficient use of climate-smart agriculture and other mitigation and adaptation techniques (FAO 2010). Expanding extension systems, especially in developing countries, is one way to achieve this goal (FAO 2010; Davis 2004). Depending on the local and national contexts, governments, universities, private research organizations, and multilateral organizations can all be involved in providing resources for such an effort. Farmer Field Schools are one way the FAO is currently working to expand these resources (FAO 2010).

Additional strategies that have limited evidence but are showing potential include testing policy measures such as subsidies and certification systems for implementing climate smart agriculture, such as improved soil and livestock management (FAO 2019a). The evidence that such strategies can be effective in mitigating and adapting to climate change is strong, but players across the food system need incentives and resources to implement them (Kopittke et al. 2019). Public, civic, and private entities all have a role to play in advancing agricultural research and development. Governments can develop regulatory, incentive, and pricing schemes that advance implementation of climate smart agriculture. All parties can fund, carry out, and disseminate research as well as provide monetary and other resources, especially through expansion of extension services, to stakeholders.

## Agricultural Livelihoods

Seventeen advocacy monographs address the economic and social aspects of food insecurity by recognizing the need to promote prosperity among food producers and communities more broadly as climate change exacerbates food security. These papers examine initiatives that engage women, young people, people in rural communities, and people living in poverty in adapting food systems to climate change. Many of these initiatives go hand in hand with those in previous and subsequent sections, such as greater emphasis on climate smart and ecosystem services–based agriculture and innovative financing systems. For brevity’s sake, the focus in this assessment is on the ways that those practices may further promote food security and climate adaptation by enhancing livelihoods and the economic security of different people.

A broad set of these studies recommend trainings, especially those that target women and/or young people. Activities include development of resilient agricultural value chains linked to youth entrepreneurship, youth participation in climate meetings with multilaterals, youth climate strikes, gender-responsive stakeholder mapping, and gender-targeted agricultural training (GCA 2019; CCCD 2009; Charles, Kalikoski, and Macnaughton 2019; FAO 2018a; FAO and CARE 2019; FAO 2019 “Youth”; GRP 2019; Nelson and Hill 2019). According to the FAO, providing women access to the same resources as men would increase agricultural productivity 30 percent (FAO and CARE 2019). All agricultural initiatives noted in previous and subsequent sections can be tailored toward women and young people by the same parties, although civic and multilateral organizations already have a track record of doing so.

These studies outline a set of economic tools to support livelihoods. These tools include diversifying sources of farm income and cash and voucher programs such as conditional and unconditional cash transfers, nutrition vouchers, and input vouchers (Burke, Marshall, and Lobell 2009; CCCD 2009; FAO 2018a). Broader economic activities to promote food security and climate change adaptation in terms of livelihood include better governance of land and water resources to prevent and manage conflicts, especially governance strategies that recognize the rights and sovereignty of indigenous peoples (FAO 2018a; GCA 2019). Public entities are well-positioned to expand resource governance and provide incentives to train new producers or provide existing producers with additional skills and resources, but multilateral and civic entities can play a role in resource governance as mediators or invest in producers. See the section below on insurance and financing for more details on these strategies, which can then be targeted toward producers with the lowest incomes, women, and young people.



These studies also present implementing famine EWS and avoiding maladaptation (especially through migration) as activities that support livelihoods. As climate change threatens food security and livelihoods generally, people migrate in search of better opportunities (Jacobson et al. 2018). However, some evidence demonstrates that migration may not be an effective way to reduce poverty stemming from climate change (Jacobson et al. 2018; Charles, Kalikoski, and Macnaughton 2019). Expanding economic opportunity and increasing resilience to disasters will help expand time horizons for vulnerable groups and avoid maladaptive measures such as migration that provide short-term help but limited long-term livelihood enhancement (Jacobson et al. 2018; Charles, Kalikoski, and Macnaughton 2019; GCA 2019). Expanding warning systems for disasters like famine is one way to promote this resiliency that all parties can play a role in funding, developing, and/or disseminating (Funk et al. 2019). Other measures to reduce maladaptation fall in line with strategies addressed in other sections of this report.

## **Insurance and Financing**

Eight studies were identified as relevant to this area, consisting of exploratory studies or advocacy monographs published by nonprofit organizations and in scientific journals and journals that are not peer-reviewed. These studies cover public and private insurance and related risk management tools that protect food security, particularly growers. They present various tools for financing agricultural climate adaptation. These tools include index insurance; weather index insurance; whole farm insurance, revenue protection; yield protection; reductions in subsidy percentages across coverage levels; subsidy reductions on revenue products; reductions in company reimbursements; county-level deep loss programs; the World Food Program's Productive Safety Net Program; the World Food Program's R4 Rural Resilience Initiative, including microinsurance; flex cash leases; pricing instruments; income and cash flow assurance (debt service protection and farmer savings accounts); and reduction of policies that limit fruit and vegetable production (Barnett et al. 2016; Barnett and Stockwell 2016; Beohlie and Hofin 2014; Linnerooth-Bayer et al. 2011; O'Hara 2012a, 2012b; Woodard 2016; World Food Programme and Oxfam America 2018).

Transitioning to climate smart agricultural will require short-term trade-offs in terms of up-front costs, lag time, or reduced yields before long-term food security, climate, and health-related outcomes are realized (FAO 2010). Developing innovative financing and insurance mechanisms to mitigate the risks associated with these costs is imperative to ensure a food-secure future (FAO 2010). Index insurance programs are one such option (FAO 2010). In this system, producers are insured against something that can be measured on an index like rainfall (Linnerooth-Bayer et al. 2009; FAO 2010).

Insuring against such events rather than actual crop losses reduces the overall costs and may increase the incentive to adapt (Linnerooth-Bayer et al. 2009). The R4 Rural Resilience Initiative has shown initial evidence for climate adaptation in agriculture by offering microinsurance to farmers in western, eastern, and southern Africa, and there is potential for governments, other nongovernmental organizations (NGOs), and private entities to expand such programs as part of a larger risk management strategy (World Food Programme and Oxfam America 2018).

Social safety nets are a more traditional financing approach and include mechanisms such as cash transfers, food distribution, seed and tool distributions, and conditional cash transfers (FAO 2010). The R4 Rural Resilience Program also included these strategies, demonstrating that combining various financing and insurance mechanisms to reduce risks associated with climate adaptation in agriculture may be effective (World Food Programme and Oxfam America 2018). Governments or NGOs typically provide such supports, but private entities could become involved through insurance (FAO 2010; World Food Programme and Oxfam America 2018). Payments for environmental services are another tool that can provide funding for climate smart agriculture (FAO 2010). Carbon financing schemes are one version of this tool. One example of this is when producers are paid to allow land to be fallow and recover (FAO 2010). Other nontraditional financing sources include taxes on international transportation emissions or financial transactions; carbon taxes; bonds; auctioning of allowances in a cap-and-trade system; and a global carbon market (FAO 2010). These financing mechanisms have been led by both private and public entities (FAO 2010).

## **Resource Stewardship**

Improved stewardship of natural resources such as soil and water can promote health ecosystems and advance food security. Resource stewardship strategies include crop diversification, soil maintenance and forestry practices, fishery management, and innovation in irrigation.

### **CROP DIVERSIFICATION**

We identified three studies—an exploratory study, case study, and an advocacy monograph published in scientific scholarly journals—that pertain to crop diversification. These studies focus on diversifying crop species to boost production and preserve soil and human health. One paper focuses on how the homogeneity of main global crops affects the global food supply, market, and nutrition. A second study similarly explores and offers solutions for diversifying the most globally consumed staple crops to keep up with the increasing demand for food because of population growth, as well as the need to preserve biodiversity for global ecosystem and human health. The final study calls for greater attention to

conserving crop wild relative species, which are close relatives of staple crops that can be cultivated to preserve biodiversity.

Maintaining and promoting a diverse set of plants and other living species within an ecosystem are crucial for the overall health of ecosystems and the humans who consume food from those systems (Khoury et al. 2014). Biodiversity has dropped with the rise of modern agriculture, and this decline threatens the resiliency of global ecosystems, which in turn damages human food systems and health. A growing number of national food systems rely on an increasing supply of a less diverse and less nutritious set of staple crops, such as wheat, corn, and rice. Using policy and other tools to preserve and expand the genetic diversity of crops around the world is key for maintaining global access to nutritious foods and keeping ecosystems healthy to continue producing food. Climate change may adversely affect the production of the most produced crops across the globe. Finding ways to expand crop diversification as a proactive means of preserving ecosystems and promoting human nutrition is especially important, as is ensuring that food supplies are not threatened.

Expanding the set of crops widely consumed by humans is also essential for climate adaptation because many “underutilized” crops have characteristics that are more resilient than those of commonly consumed crops (Massawe et al. 2016). This includes resistance to drought, floods, pests, diseases, and temperature fluctuations/extremes. Expanding the growing of resilient and nutritious crops such as quinoa, amaranth, and groundnuts would be a step toward creating a food system, an ecosystem, and a global society that are more resilient. Other climate-resilient crops that can promote food security are fruits and vegetables such as jackfruit and mangosteen, legumes such as winged beans and jering, tubers and roots such as Mashua tubers and rootstocks, and cereals such as buckwheat and pearl millet.

Conserving crop wild relative (CWR) diversity is another approach to ensuring food security in a changing climate (Vincent et al. 2013). Crop wild relatives are essentially the “cousins” of staple crops like wheat, soy, or rice<sup>4</sup> (Vincent et al. 2013). Although multilateral organizations like the FAO have recognized the importance of conserving crop wild relatives, conservation efforts often focus on nonfood sources such as large habitats/parks or charismatic megafauna (Vincent et al. 2013). The creation in the past decade of the crop wild relative inventory<sup>5</sup> is an important first step toward documenting species that not only should be targeted for conservation but could be more widely produced as food commodities (Vincent et al. 2013). Crop wild relatives that cannot be grown as food should still be protected and expanded because their genetic diversity helps protect their crop relatives from disease, therefore enhancing crop yields.<sup>6</sup> For example, genes from crop wild relative bananas have been used to cultivate fungus-resistant banana varieties produced for global consumption. Crop wild relative genes can also be used to promote tolerance to drought, salt, and pests.

The Crop Wild Relatives Project is an NGO that operates with other NGO partners globally. Although the International Treaty on Plant Genetic Resources for Food and Agriculture (2001) is a key recognition of crop diversification as a priority for climate adaptation and food security, many opportunities exist for additional public and private parties to become involved in preserving and expanding crop diversity for climate adaptation, ecosystem resilience, and human health (Vincent et al. 2013). Also, more research is needed to locate and collect crop wild relative species (Vincent et al. 2013). Foundations, NGOs, governments, and for-profit entities can fund and carry out this research. Next steps include prioritizing and mapping crop wild relative species, cross-breeding crops with wild relatives to increase resilience and yields, and expanding the cultivation of underutilized crops (Khouri et al. 2014; Massawe et al. 2016; Vincent et al. 2013).<sup>7</sup> Similarly, all types of organizations can play a role in promoting these actions; foundations, for example, can provide support for crop inventories and government and multilateral programming and investment in biologists, farmers, and other food companies, including expanding subsidies to more crops. Given the definitive level of evidence on the importance of crop diversification—including the use of crop wild relatives and underutilized crops—for ecosystem and food system resilience, crop diversification action must be taken now.

## SOIL MAINTENANCE AND FORESTRY PRACTICES

We identified eight exploratory and case studies from scientific scholarly journals and advocacy monographs that examine planting and soil maintenance practices. These studies pertain to subjects such as forestry and agroforestry, soil fertility (including fertilizers and nutrients), cropping schedules, and land sharing/sparing.

Soil degradation has long been a challenge in agricultural production, but industrial agriculture and rising populations have exacerbated the problem. Additionally, climate change–associated weather events such as floods and drought can damage already strained soil systems and further deplete soil (Kopittke et al. 2019). Healthy soil is crucial to maintaining crop yields and providing ecosystem services such as carbon sequestration, greenhouse gas management, and flood buffering. Ninety-nine percent of human food is grown in soil, so maintaining soil health is also necessary for ensuring a steady food supply. Degradation is already occurring at unsustainable rates because of the pressure on soil systems.

Fertilizers such as phosphorus are necessary for maintaining healthy soil but have been overapplied (Chowdhury et al. 2017). This pollutes waterways, causing harmful growth of eutrophic bacteria that threaten water ecosystems. Phosphorus is not a renewable resource, nor are there alternatives to its use. Scholars have put forth various possible measures to reduce demand for phosphorus, make phosphorus and other nutrient use more efficient, equalize access to fertilizers, and decrease

waste/runoff in food and agricultural production. Strategies such as soil surveying; altering the crops that are planted; hydroponics; and best management practices such as strip-till, no-till, cover crops, riparian buffers, and manure storage can help farmers across the globe use less phosphorus, increase crop phosphorus take-up, and reduce phosphorus runoff into waterways (Chowdhury et al. 2017; FAO 2010).

Governments and civic/NGO entities can provide incentives to producers that implement these practices. Parties such as multilateral development institutions, extension services, and natural resource departments can provide soil surveying and train producers to use fertilizers more efficiently. Given the strong evidence for these practices in promoting more sustainable fertilizer use, scholars recommend allocating resources toward testing and implementing these practices rather than additional research. There is strong evidence that these practices reduce soil degradation, but producers have little economic incentive to implement them (Kopittke et al. 2019). Providing and testing incentives is imperative for reducing soil degradation and thereby mitigating and adapting to climate change and preventing a global food supply crisis. Allocating funds to educational and producer initiatives that reorient people and societies to the importance and economic value of soil health is also crucial (Kopittke et al. 2019).

The evidence is strong that agroforestry promotes ecosystem health and can increase biodiversity and producer income while maintaining crop yields (Neufeldt et al. 2009; Waldron et al. 2017). However, comparatively little investment has been made in agroforestry (Waldron et al. 2017). Planting trees on farms and developing forest-/tree-based agriculture can support soil health; provide ecosystem services such as shade, nutrient provision, and habitat for other synergistic organisms; help mitigate the effects of weather extremes associated with climate change; and diversify the incomes of producers, especially smallholder farmers (Neufeldt et al. 2009). Waldron and coauthors (2017) recognize that even though agroforestry crop yields may not be as high as those of conventional growing techniques, they are high enough to meet demand.

The benefits of agroforestry may also outweigh the costs of any maximal yields associated with conventional growing (Waldron et al. 2017). Providing producers with both agroforestry training and economic incentives to switch to agroforestry techniques, including planting more trees on agricultural land, is another possible means of addressing food security in a changing climate. All types of institutions—including governments at all levels, as well as NGOs and multilateral organizations—can develop and target interventions related to agroforestry. While opportunities to implement agroforestry exist globally, interventions will need to be tailored based on the size of the producer, the local habitat (crops, trees, and other organism species), and the rural/urban location.

## FISHERIES

Four recent monographs (exploratory or case studies) published by the FAO pertain to fisheries (wild fish) and aquaculture (farmed fish) vulnerabilities to climate change, as well as management and adaptation. These studies note the overall expansion of fisheries and fish consumption in recent years and the importance that fisheries and aquaculture have in supporting livelihoods around the globe (FAO 2007, 2018b; Cochrane et al. 2009). Studies focused on both saltwater and freshwater sources of fish. Tools to address fisheries adaptation include an ecosystems approach to aquaculture, aquaculture insurance, research and technology transfer, aquaculture zoning and monitoring, and integrated coastal management.

As with agriculture, an ecosystems approach necessitates bringing together stakeholders across all scales to coordinate resource sharing and integration and is well-documented as an effective approach (Cochrane et al. 2009; FAO 2018b). Recognizing watersheds as relevant boundaries to agriculture and other planning is also imperative (Cochrane et al. 2009). Shrimp farming communities in eastern India have implemented a watershed approach that regulates insurance within that boundary (Cochrane et al. 2009). Implementing strong monitoring systems at the watershed level is key to receiving early warnings about diseases, pests, algae blooms, and other changes to water conditions (Cochrane et al. 2009). As with crops, diversifying species is one way to make aquaculture more resilient to climate change, and that practice has expanded rapidly across the globe in recent years (Cochrane et al. 2009). Public entities can use insurance and other financial incentives to promote diversification (Cochrane et al. 2009). Public, private, and civic entities can play a role in educating producers and consumers about a more diverse fish supply (Cochrane et al. 2009). The same entities can provide resources such as temperature monitors, Secchi disks (a device used to measure eutrophication), and other tools, as well as education on how to use them to enhance watershed monitoring (Cochrane et al. 2009).

Spatial planning is another potential area of activity in aquaculture (FAO 2018b). It involves mapping aquaculture systems (including governance and risk), monitoring ecosystem capacity to support aquaculture, conflict management, development of geographies for certification, and co-location of aquaculture with transportation and/or markets (FAO 2018b). Other adaptation measures include reducing fishing in overfished areas, bringing together institutions across sectors to build bodies of knowledge and institutions of people to respond to climate threats, bridging gaps between disaster response and adaptation systems and fisheries/aquaculture management (e.g., storm barrier conservation like wetlands as well as warning and recovery systems), and establishing multilateral agreements around fishery and aquaculture borders and governance (FAO 2007).

Public, private, and civic entities can all play a role in bringing together stakeholders, providing funding for, and disseminating resources for an ecosystems approach to aquaculture, spatial planning, reducing overfishing, coordinating and building institutions, integrating disaster response systems, and establishing governance agreements. For example, any of these groups could provide mapping tools, services, or resources to watersheds to improve spatial planning. Or they could innovate funding and education around wetland conservation to improve flood resilience in coastal areas. Convening stakeholders to develop governance agreements is another example of an activity.

## IRRIGATION

A handful of recent monographs—exploratory and case studies published in scientific scholarly journals or by the FAO—pertain to watershed adaptation, water management, and water scarcity. Nature-based solutions for water management are a potentially viable option for transforming water management paradigms and practices (Matthews et al. 2019). Many of these strategies overlap with those already discussed regarding agricultural research and development and planting and soil maintenance practices.

Climate change will result in greater water stress for populations worldwide, but most notably in the Mediterranean, central and southern Africa, Europe, and Central and South America (Arnell 2004). Such water scarcity will further stress agricultural systems (Arnell 2004; Sonneveld and Merbis 2018). Luckily, various water management strategies exist that can reduce unnecessary water loss by systems and promote climate smart agriculture (Branco et al. 2005; Sonneveld and Merbis 2018). Like strategies related to planting and soil maintenance, water infrastructure that works with ecosystem services is one viable option. Evidence shows that any approach to adapting water management must engage and reward stakeholders at all levels, particularly those at the grassroots level (Branco et al. 2005; Sonneveld and Merbis 2018). Water management practices such as ecological infrastructure (e.g., thicket rehabilitation), earthen banks/dams, sand dams, terracing planting, qanat irrigation, small-scale irrigation with other climate smart land management, compost pits, raised beds, green infrastructure, buffer strips, and no-till planting have been effective in certain contexts, such as more rural and less developed areas (Sonneveld et al. 2018).

Financing practices that include water trust funds, such as one in Quito, Ecuador, or payment for ecosystem services show some evidence of success. Additional testing of these schemes is one area of possible activity for all public, civic, and private entities. These groups can also convene stakeholders to discuss and begin implementing these practices. Other possibilities for all groups include disseminating information to stakeholders about how to implement these strategies, especially through extension services.

## WASTE

We also identified studies that pertain to food waste and holistically examine food system impacts. Reduction of food waste is another integrated approach to improving food security and mitigating climate change (Drangert, Tonderski, and McConville 2018; Ingram 2011; WHO 2018; WRI 2019). Food waste occurs in different parts of the supply chain in different parts of the world (WRI 2019). In North America, more than 60 percent of food loss happens at the consumer level (WRI 2019). In sub-Saharan Africa, meanwhile, only 5 percent of loss is at the consumer level because nearly 80 percent occurs at the production, handling, and storage levels (WRI 2019). Rebuilding systems that reduce waste and promote education among food producers, processors, and/or consumers is crucial to reducing greenhouse gas emissions and promoting food security (Ingram 2011; WRI 2019). All parties can play a role in restructuring these systems, whether it be governments in North America improving zero waste planning and infrastructure for consumers or those in sub-Saharan Africa providing better resources for pest-, drought-, and disease-resistant crops (Myers et al. 2017). Additionally, the European Union solid waste hierarchy represents an effective approach to reducing solid waste, particularly phosphorus waste, as well as waste recovery (Drangert, Tonderski, and McConville 2018).

## Nutrition

We identified six case and exploratory studies that focus on the human health aspects of climate-stressed food systems change. Simulation modeling shows that climate change may exacerbate deficiencies of nutrients such as protein, iron, and zinc, particularly in areas already experiencing such challenges (Beach et al. 2019). Combating hunger necessitates agricultural growth that may have adverse effects on climate (Baldos et al. 2014; FAO 2019a). As stated in previous sections, developing climate smart agriculture is imperative to addressing both issues simultaneously. Reducing overconsumption and obesity, often a different side of the food insecurity coin in developed nations, can also help bring about global food security (FAO 2019a). Calls to reduce consumption of meat and other sources of animal protein are often simplistic, but policymakers, private companies, and civic organizations can play a role in a responsible transition away from some of these sources, particularly in more developed parts of the world (de Boer and Aiking 2011).

Possible activities include testing subsidies or other financing mechanisms for more varied protein sources, including funding laboratory development of plant-based proteins and incentives for producers to transition from livestock to crop production (de Boer and Aiking 2011; FAO 2019a; Myers et al. 2017). Enhanced consumer education on nutrition and the environmental impact of different food sources is another route (de Boer and Aiking 2011; Myers et al. 2017). And increasing subsidies for



fruits and vegetables, particularly in the United States, is an action all parties can be involved in (O'Hara 2012a, 2012b).

Finally, possible activities also include further integrating health systems with food systems and broader climate adaptation measures (WHO 2018). One example of this would be expanding the number of public health workers within sectors such as food, water, sanitation, and energy (particularly for public and civic entities, but also for private companies in these sectors). In terms of preventive health, implementing climate smart agriculture practices outlined in previous sections would be a strong path to mitigating both climate change and its consequences to food security (WHO 2018).

## The Opportunity

Myriad strategies for addressing food security exist in the realms of agriculture research and development (including livestock production and plant genetics), water, fisheries, crop diversification, planting and soil management practices, insurance, human health/nutrition, and livelihoods. Scaling up “climate smart” agriculture involves improving synergy of natural ecosystem services with food production (FAO 2010, 2019c). Finding ways to efficiently transition to these practices at large scales, rather than continuing the status quo of inefficient use of inputs (such as water and fertilizer) to produce a narrow set of food sources that have adverse effects on human and ecosystem health, represents the crux of the food security challenge in a changing climate.

Agricultural research and development has been the catalyst thus far for developing climate smart agriculture. Most of these tools overlap with additional strategy areas such as crop diversification, water supply and management, planting and soil maintenance practices, nutrition/human health, and livelihood. Key strategies to addressing food insecurity include biodiversity conservation, particularly the diversification of major crop species, as well as conservation of crop wild relatives (Khoury et al. 2014; Vincent et al. 2013). Developing heat, drought, flood, disease, and pest resistant cultivars is also imperative to meeting demand as the population grows and the climate changes (FAO 2010; Vincent et al. 2013). Planting strategies from simple strip-till to complex agroforestry system can reduce water and fertilizer inputs and runoff and improve soil health and productivity, as well as diversify crop production and therefore producer income sources and human food sources (Butt et. al. 2005; Chakraborty and Newton 2011; Dhankher and Foyer 2018; FAO 2010). Making livestock production more efficient can conserve land and water resources while maintaining valuable nutrition sources for different populations (Davis and White 2020; FAO 2019). Ecosystem-based approaches to fisheries and aquaculture maintenance will also ensure efficient management and governance of watershed systems

because such approaches involve integrating stakeholders across the supply chain (Cochrane et al. 2009; FAO 2018b).

Reducing food waste across all parts of the supply chain can mitigate greenhouse gas emissions and improve food security through reduced loss and landfill use (Ingram 2011; WRI 2019). Strategies to address food loss across the supply chain include reducing loss through pest-, drought-, and disease-resistant crops and implementing zero waste infrastructure (Myers et al. 2017; WRI 2019).

Developing innovative financing and insurance schemes is critical to incentivizing actors at all parts of the food supply chain to transition to these solutions. Many of these practices have larger up-front costs (Linnerooth-Bayer et al. 2011). The return on such investments will happen in the long term, but so too are the severe consequences of maintaining the status quo (Linnerooth-Bayer et al. 2011; IPCC 2014). Additionally, as a changing climate increases risks of food loss because of heat, flooding, pests, and disease, insurance is critical to protecting producer livelihoods (FAO 2018a). Strategies such as index, micro, and other forms of insurance can protect producers from these risks and increase their incentive to adapt agricultural techniques (Linnerooth-Bayer et al. 2009; FAO 2010; World Food Programme and Oxfam America 2018). Other forms of financing, such as payment for ecosystem services, reduce up-front costs to transitioning (Linnerooth-Bayer et al. 2009; FAO 2010; World Food Programme and Oxfam America 2018).

In short, the categories of opportunities available in this action area include the following:

- funding direct research efforts, or advocating for additional funding from international, national, and philanthropic funders
- supporting the resilience safety net like that proposed in the direct financial services action area but targeted toward rural, agricultural communities
- promoting funding and insurance coverage for crop diversification and failures, respectively, like the explorations in the public finance and insurance action areas but, again, targeted to this specific sector (Similar approaches could be considered for fishermen, livestock ranchers, forest managers, and other stewards of food supply chains.)
- tailoring appropriate water management solutions for individual agricultural contexts
- developing nutritional guidance programs and regulations that promote changes in food demand

Ultimately, the set of opportunities in this action area are too numerous to describe in a single tome, and require an extensive exploration with global food and agricultural organizations in order to advance to the point of implementation. Given the populations that are still dependent on agricultural work and the obvious reality of growing food demand, however, this action area may merit that exploration.

Some practitioner reflections on future actions in this area are worth noting. Experts interviewed cited climate change as increasing the complexity of food systems and point to an increasing recognition of the fact that, despite their benefits, available solutions may also have negative ecological and socio-economic impacts. At issue is how to answer the question of integrating fundamental questions of food security and livelihoods with concerns about sustainability, against the background of stressors to food systems, like urbanization and environmental degradation. While Goal 2 (Zero Hunger) of the Sustainable Development Goals might provide an organizing framework for action in the context of a changing climate, the increasing complexity of the field might make it difficult for donors and other stakeholders to articulate their prospective roles in and contributions toward “the future of food.” Notwithstanding, there is an unambiguous role for governments around the world to invest in global public goods that boost resilience of food systems (e.g. crop diversity), as private actors are unlikely to serve those interests in the long term. Strategies for implementing opportunities in this area should, however, consider the capacity building that countries might need to undertake such global public good investments.

Finally, because the food security and climate adaptation intersection tends to be a niche area, socializing relevant audiences to the area’s needs and potential benefits would go a long way in uncovering opportunities for future interventions, tailored to the unique capacities of different actors.

## Unit of Intervention

The units of intervention vary as much as the nature of opportunities, from agricultural researchers, to individual farmers and their households, to regional watersheds, and including individual consumers.

## Scale of Intervention

The range of projects suggests a wide beneficiary pool for their products, if successful. For example, the scale of potential products from research is global. In contrast, the market for opportunities that focus on individual farmers’ practices and businesses (livelihoods, insurance and finance, and resource

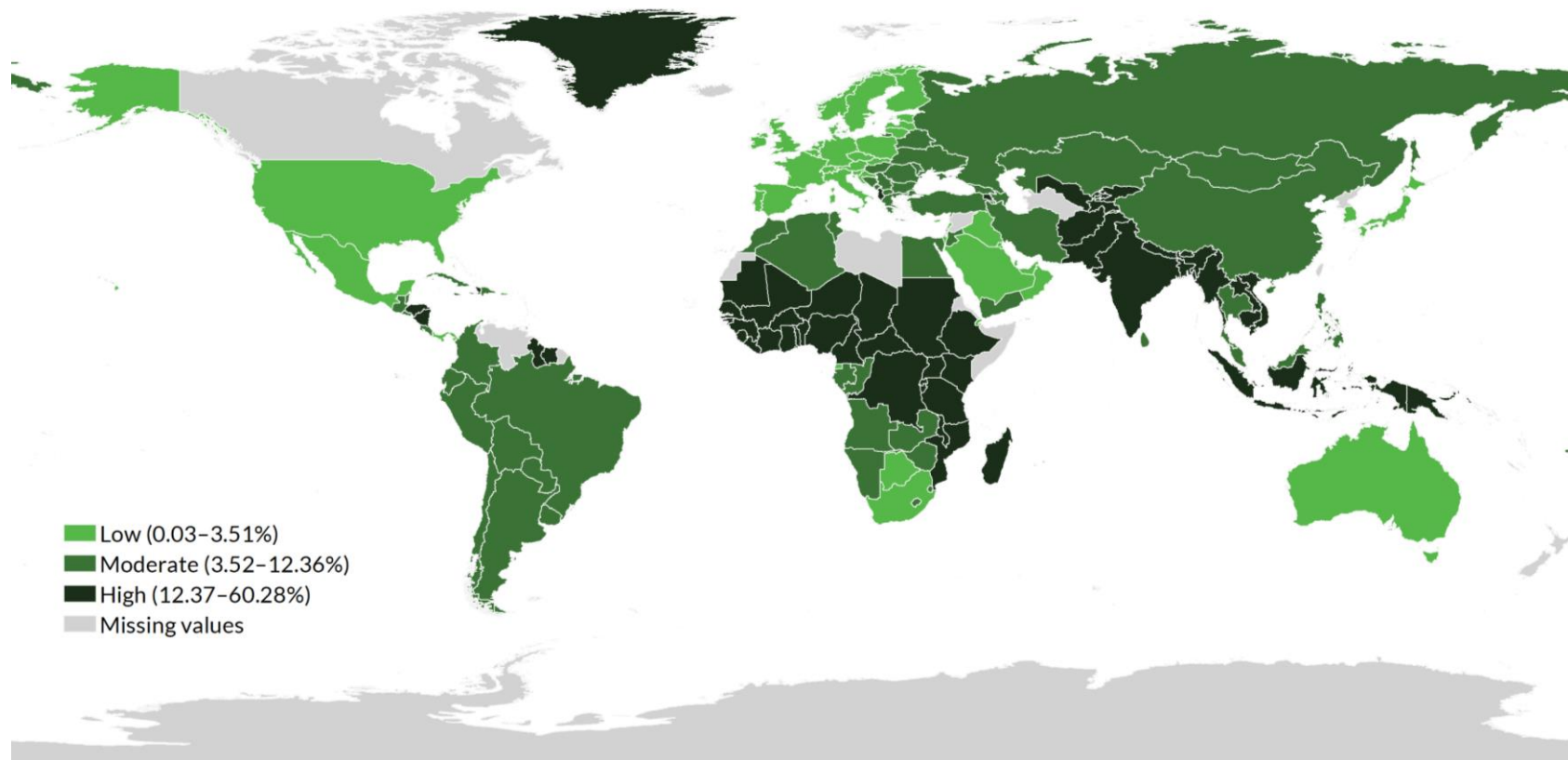
stewardship) would be defined by the collection of farmers in developing contexts (especially nations with significant low-income, rural populations) that require additional capacity building and resources. The same holds true for other sectors, such as fisheries, forestry, and livestock. For nutritional changes, changing the food behaviors of high-income and middle-high-income nations that consume the least sustainable food would be the maximum relevant reach.

Nations whose economies continue to rely heavily on agricultural production (figure 24), particularly in sub-Saharan African, South Asia, and Southeast Asia could benefit from further technological, insurance, livelihood, resource stewardship interventions. Alternately, nations that face persistent food insecurity—which include many in developed contexts—could benefit from nutritional interventions.

In both cases, though, continuous monitoring of locations for the continual increases in heat (figure 25) and precipitation (figure 26) will continue to shape the full supply chain, from farm to table.

FIGURE 24

Agricultural Production as Percentage of GDP, 2018

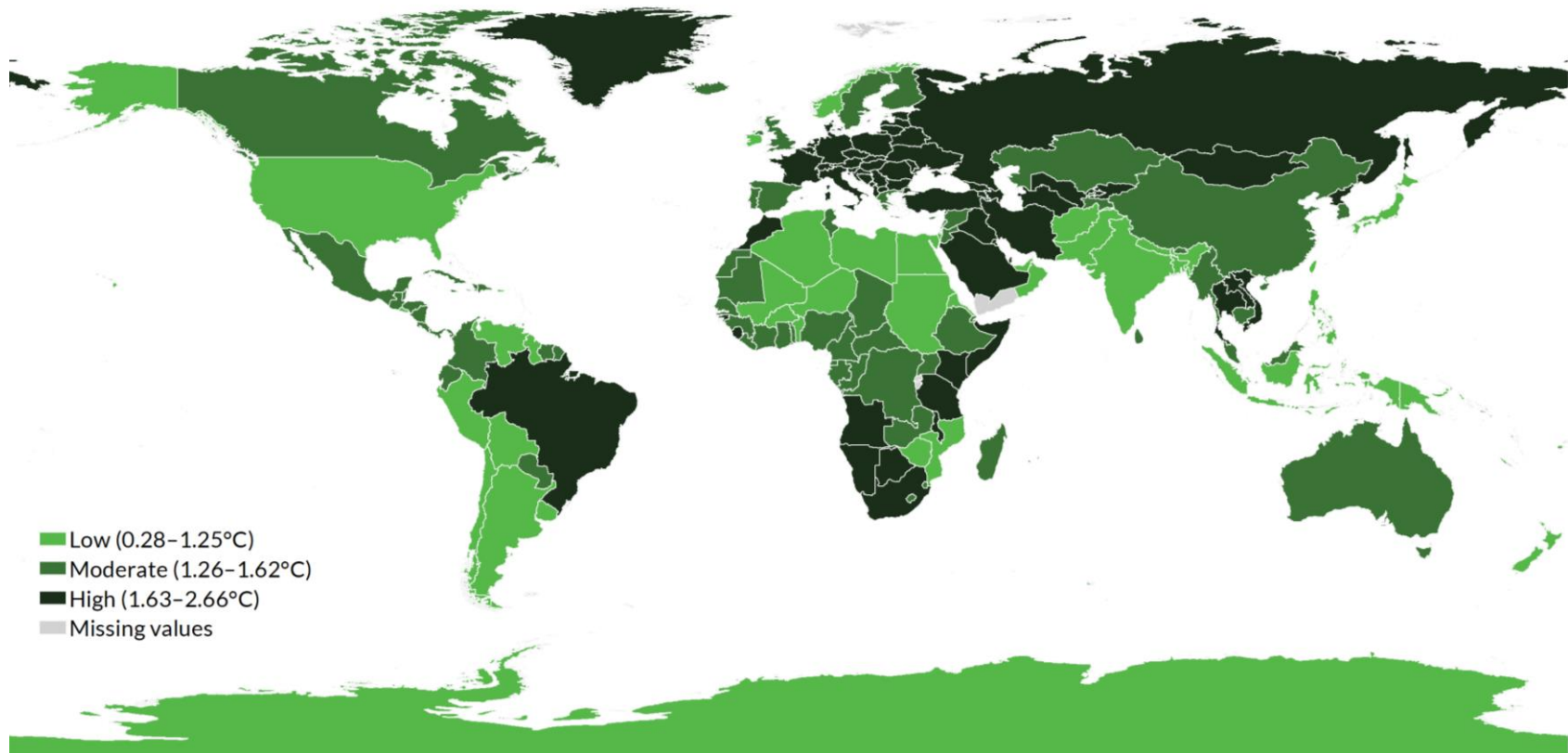


URBAN INSTITUTE

Source: "Agriculture, Forestry, and Fishing, Value Added (% of GDP)," World Bank, accessed April 1, 2020, <https://data.worldbank.org/indicator/nv.agr.totl.zs>.

FIGURE 25

Temperature Change, 2019

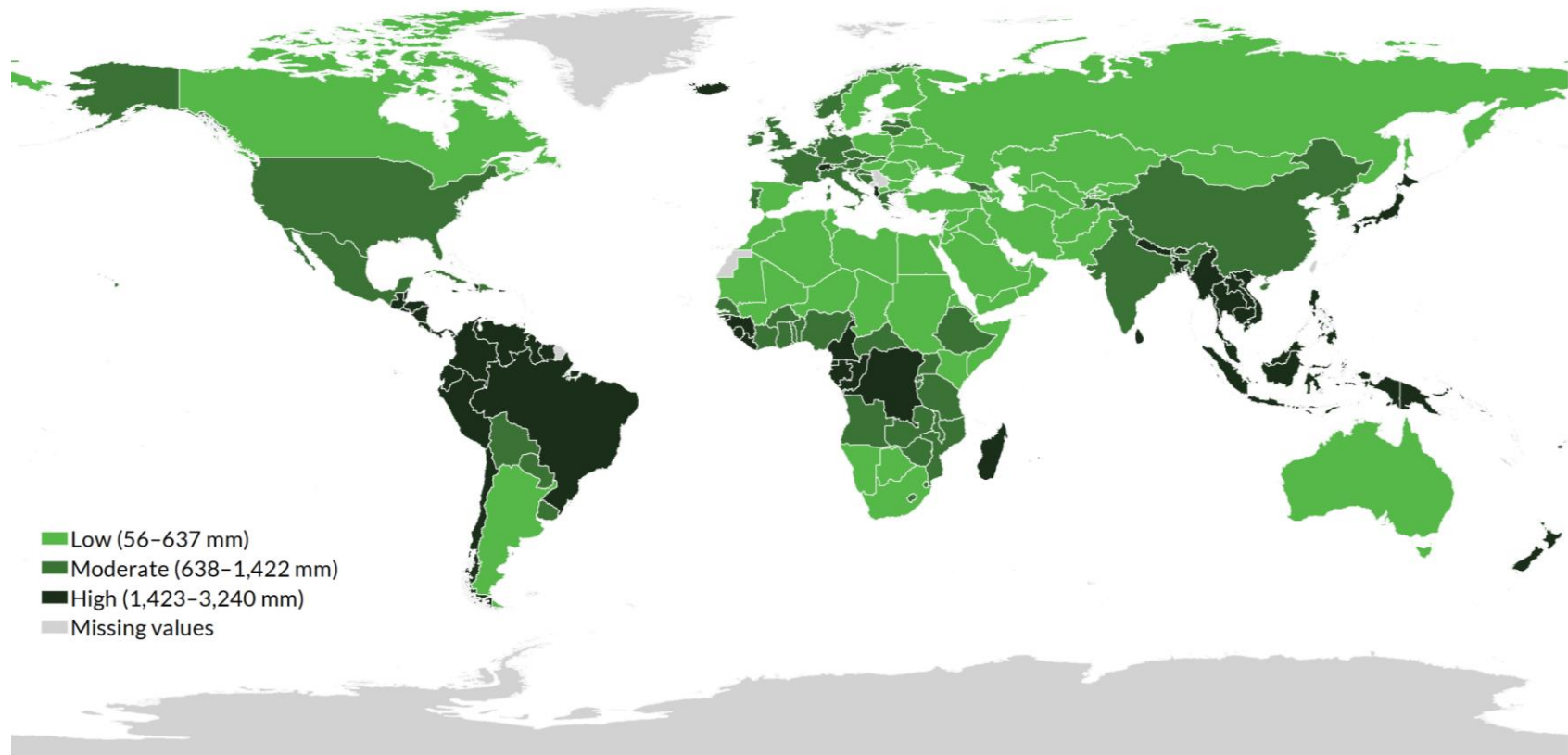


URBAN INSTITUTE

Source: "Temperature Change," UN Food and Agriculture Organization, accessed April 1, 2020, <http://www.fao.org/faostat/en/#data/ET>.

FIGURE 26

Precipitation Change, 2014



URBAN INSTITUTE

Source: “Average Precipitation in Depth,” World Bank, accessed April 1, 2020, <https://data.worldbank.org/indicator/AG.LND.PRCP.MM>.

## Summary

Perhaps more than any of the other action areas under review, the five categories presented in this food security action area represent the most complex and interconnected sets of opportunities.

Furthermore, many of these opportunities are either extremely resource-intensive (such as research or changes in nutritional behaviors) or they are place-dependent, reliant on working to transform existing and, in some cases, ages-old agricultural practices with modern techniques, funding sources, and protections. Both scenarios require significant public and development assistance, though there is compelling preliminary evidence for the opportunities in question. Strong evidence also supports interventions for subsets of the individual households involved in agricultural sectors, such as women, ethnic minorities, and subsistence farmers.

For all these opportunities, there is an existing infrastructure of multilateral and civil-sector organizations that have been involved in agricultural policy and industrial interventions at the global scale. Most have, like the UN Food and Agriculture Organization and development agencies such as those in the US and UK, have worked in key national and subnational contexts. Vehicles like these could prove to be the most efficient partners for reaching local farmers and farm service providers particularly given the resource needs and existing infrastructure that could be harnessed for resilience ends.

## Notes

- <sup>1</sup> “EX-Ante Carbon Balance Tool,” Food and Agriculture Organization of the United Nations, accessed February 16, 2020. <http://www.fao.org/tc/exact/ex-act-home/en/>.
- <sup>2</sup> “AquaCrop,” Food and Agriculture Organization of the United Nations, accessed February 16, 2020, <http://www.fao.org/aquacrop/en/>.
- <sup>3</sup> “Information on Post-Harvest Operations,” Food and Agriculture Organization of the United Nations, accessed February 16, 2020, <http://www.fao.org/in-action/inpho/home/en/>.
- <sup>4</sup> For more information, see “The CWR Project,” <https://www.cwrdiversity.org/project/>.
- <sup>5</sup> “About Crop Wild Relatives,” The Crop Wild Relatives Project, accessed February 16, 2020, <https://www.cwrdiversity.org/about/>.
- <sup>6</sup> “About Crop Wild Relatives,” The Crop Wild Relatives Project.
- <sup>7</sup> “About Crop Wild Relatives,” The Crop Wild Relatives Project.



# Conclusion

Many of the potential strategies for implementing the opportunities in this report remain aspirational; there is only a modest evidence base from which to glean efficacy as well as estimate the resource intensity needed to accomplish them. This circumstance holds true largely because there have been so few instances of these actions to date. Even where specific tools have existed—such as financial safety nets or emergency alert systems—they have yet to be employed for the shocks faced in contemporary society such as climate change’s effects or, for that matter, pandemics.

Regardless, the fact that the action areas and their respective opportunities emerged from internationally developed, peer-reviewed, global consensus documents and were corroborated through interviews with thought leaders bears repeating. There are, in fact, dozens if not hundreds of potential resilience solutions that can be explored. Many of these fit squarely within the capacity of organizations seeking to provide seed investments and develop pilot partnerships. Even after the primary filters of evidentiary support, immediate implementability, scalability and replication, and leveraged partnerships are imposed, a myriad of opportunities continue to surface.

This terrain of opportunity exists essentially because the demand for resilience building is so great. Communities that are the most exposed to hazards and have the least resources are ultimately those that are most vulnerable to shocks of all kinds and in the most need of information, money, and platforms from which to design their own futures. This report has specified a few of the opportunities with the most potential to work in the select places to help these people.

In addition to the specifics detailed in this report and synthesized in the starting summary, the research team has developed general guidance based on implementation studies within resilience scholarship, as well as from comments provided by the thought leaders who were interviewed during this assessment about their own lessons.

## Specifying the Shock

The first suggestion is around the challenge introduced at this report’s onset—the lack of specificity in naming the shock that a resilience opportunity is meant to mitigate. Naming the shock helps define who needs to be resilient, which structures or institutions have exacerbated gaps in past resilience capacity, the current framework of services associated with that shock, and what future interventions can be made to help. In fact, the opportunities presented in this report largely focus on the acute and chronic

shocks associated with climate change's effects and their consequent impacts on displacement and security. Except for some scholarship and practical tools from the emergency management literature, most of the resilience literature to date comes from that climate change perspective. Even then, several thought leaders interviewed for this report pressed for an even sharper focus beyond all climate change's effects to specific ones, such as increased heat or flooding exclusively.

Only two types of interventions might fall out of this requirement to specify the shock in the interventions' goals. The first are the actions that address an underlying stressor, such as poverty, income inequality, structural racism or sexism, etc. In the resilience vocabulary, stressors are the long-term disparities and related contextual manifestations that increase exposure or vulnerability to shocks—in essence, the social conditions that are typically exacerbated by a shock and its damages or losses. Much of the international development and safety net programming of the last century has focused on these stressors. Because correction of that stressor reduces the distributional effects of any shock on a place, these kinds of interventions need not shock-specific.

The second group of possibly shock-neutral interventions are those proposing a fundamental institutional or governance transformation. Examples of these interventions include the reorganization of city governments around the shock lifecycle (i.e., preparation and mitigation, relief and response, and recovery and stability), re-envisioning democratic processes, and aligning city, state, national, and multinational policies and programs around that same framework. Developing networks of mutual aid and collaboration between neighboring jurisdictions are another vehicle for resilient institutional change. Given the magnitude of their scope, these interventions are resource and time intensive. But, in theory, they result in new ways of organizing the public sphere that could address any shock.

For most agents in the resilience space, however, time and resources are limited. Civil-sector stakeholders often have limited appetite and capacity for either massive societal change or institutional transformation and must focus their efforts on tangible, implementable actions. Ultimately, the ambitions of the resilience movement have been constrained by the urgency of their goals—and the subsequent, realistic limitations on time and resources. Goals for any intervention are most likely to be achieved when the goals themselves are specific.

## Specifying the Vulnerable

All people and ecosystems are subject to shocks, but not all will be impacted equally or proportionally. The distribution of impacts and resources after a shock event reflect, and in most cases, exacerbate the

disparities before. Specifying whose resilience should be built is as critical a consideration as specifying the shock against which they are building resilience—if not more so, given the mission or values of the organization supporting the intervention.

Focusing on the poor and most vulnerable has been the explicit goal of most civil-sector actions, though that focus often does not ultimately manifest in changes to participatory planning and intervention design, in inclusive engagement and access to services, or in measurable, positive changes to outcomes for these communities. This is especially true for international resilience projects that straddle developed and developing contexts, in which the aid to the former often involves helping the communities or organizations who, all things considered, can build their own resilience capacity.

The mapping exercises conducted for this report outline repeating borders of need: Sub-Saharan Africa, South Asia, Southeast Asia, Central America, and the Caribbean and, to a lesser extent, the financially, politically, and socially vulnerable in middle-income nations and a few upper-income nations where disparities in vulnerability have been increasing. Many of the opportunities presented in this report, however, would face uphill battles in these contexts for numerous reasons, including: the lack of pre-existing infrastructures or platforms from which to build pilots or innovate; the gaps in local public and private sector partners' capacity; and the reticence to collaborate with external organizations developed over years of colonial paternalism. Finding the right geographic, political, and market match for some of these opportunities in other contexts (such as middle-income countries or low-income communities in upper-income ones) may be necessary for developing proof of concept before replicating elsewhere.

However, that strategy should not circumvent keeping an eye on where the need is the most. As one thought leader interviewed for this assessment noted when asked about resilience opportunities, “It is a problem that needs a solution, not a solution that needs a problem.” The focus should remain on the resilience problem, wherever it manifests.

## Specifying the Commitment

Another key lesson from past resilience building efforts involves the depth and duration of the actions in the communities with need and the sectors of interest. Community engagement literature is clear about the need to build relationships and coalitions over time to be effective. Yet, this long-term strategy creates an apparent tension with actions that need to occur urgently and across multiple geographies such as those associated with global resilience.

Critiques of past resilience efforts were based on actions at both ends of the commitment spectrum. Some actions were criticized for being too place-based and focused on local contexts, limiting their replicability in other needy places, though much of that criticism was since early resilience efforts benefited wealthier communities with enough intellectual capacity to gather resources before more disadvantaged ones. In contrast, other resilience actions were described as too heavy-handed with regards to top-down approaches and models that did not account for local governance contexts as well as grassroots approaches to problem assessment and decisionmaking.

Critiques of the time horizons of resilience efforts were similarly bifurcated, with those looking at long-term timeframes being viewed as not delivering urgent change quickly, while those focusing on “low-hanging fruits” on short order being described as quick fixes, unsuitable to the transformational changes to stressors implicit in resilience thinking. Neither approach to critiquing the timeframe of resilience actions consistently considered the material realities of project timing, such as the years of development, regulatory review, design, construction, and commissioning for new infrastructure or the staging of community participation.

Ultimately, there is no clear solution that provides a perfect balance for addressing these tensions. In fact, a key criterion for selecting opportunities in this study is their replicability—a trait that would maximize the scale of populations served. Establishing commitment principles for each of the selected opportunities early on could help define the appropriate depth and timeframe objectives, particularly between strategic pilots or demonstrations and long-term scaling. These principles could also be incorporated explicitly into their goal statements.

Resilience “is not a sector, but a cross cutting issue,” per one study respondent. Consequently, thinking of a mix of opportunities to support requires being conscious of their various time and depth commitments in unison.

## Specifying the Partners

A final, logistical lesson from previous resilience efforts is derived from their selection of partners. Often, critics viewed an overemphasis on for-profit partnerships as detrimental to civil-sector goals and the desired benefits for vulnerable populations. For several interventions, though, the need to involve private knowledge, capital, and influence is unavoidable.

To that challenge, thought leaders recommended that public- and civil-sector efforts be thoughtful about how their resource could be made to manage quantified costs and risks to accurately define the

distribution of benefits. For example, some of the concessional or grant-based finance or other low-cost lending suggested under the public finance action area directly lend themselves to appropriately shifting divisions of returns to short- versus long-term investments.

All the above lessons provide helpful guidance for the selection and implementation of new resilience opportunities. However, the careful selection of tools and the places in which to implement will not guarantee ultimate success—but success certainly will not be otherwise attainable without the kind of reflection and reliance on an evidence base. Ultimately, the need for building resilience persists and the transition into implementation is urgent.

The Urban research team encourages further transparent and thoughtful development as any resilience-building effort proceeds along that path. Fortunately, again, we know that direct resilience opportunities—interventions that are replicable for wide populations at different scales, that can leverage multiple knowledge and financial resources, and that could ideally distribute costs and risks equitably—exist.

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