BUILDING RESILIENT INFRASTRUCTURE FOR THE FUTURE

BACKGROUND PAPER FOR THE G20 CLIMATE SUSTAINABILITY WORKING GROUP

Xianfu Lu

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Building Resilient Infrastructure for the Future

Background paper for the G20 Climate Sustainability Working Group

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CONTENTS

FIGURES AND BOXES

FIGURES

BOXES

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ABBREVIATIONS

APAN	Asia Pacific Adaptation Network
CRA	climate risk and adaptation assessment
CRM	climate risk management
DMC	developing member countries
DRR	disaster risk reduction
GCF	Green Climate Fund
GEF	Global Environment Facility
ICT	information and communications technology
IDFC	International Development Finance Club
IPCC	Intergovernmental Panel on Climate Change
MDB	multilateral development banks
NDC	nationally determined contribution
PPCR	Pilot program for climate resilience
PPP	public-private partnerships
TCFD	Task Force on Climate-related Financial Disclosure
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

The Asia and Pacific region has achieved major economic growth and poverty reduction over recent decades. Infrastructure has played a key role in this success and the Asian Development Bank (ADB) has been pivotal in its financing. Over the next decade, further investment in infrastructure, estimated at $1.5 trillion a year, will be needed to maintain the growth momentum and eradicate the remaining poverty. ADB will play a major role in catalyzing this investment, as set out in its new Strategy 2030.

However, the region often experiences extreme weather events and geophysical shocks and is one of the most vulnerable globally to future climate change. There is therefore a need not only to ensure that investment in infrastructure is more resilient but also to enhance regional investment in disaster risk reduction and climate change adaptation. Against this background, there is impetus for urgent action in prioritizing, designing, executing, and scaling up investment in resilient infrastructure. This paper sets out recent ADB experience and insights in this area, and shows how these lessons are being used to take the resilient infrastructure agenda forward.

Building on experience. ADB has been a regional leader in understanding and addressing the potential impact of disaster and climate change. This experience provides valuable insights, which in turn have led to new approaches to building resilient infrastructure.

Over recent years, ADB has altered the types of disaster risk reduction investments it finances, branching out from structural projects into nature- (or eco-) based solutions, community-based resilience infrastructure, and projects that combine structural (e.g., hard protection) and nonstructural (e.g., early- warning) interventions. It has operationalized a climate risk management framework in the investment project cycle, and has been integrating climate adaptation into projects over the past 5 years, steadily increasing its financing. The methods that ADB uses to manage climate risks to investments have evolved, and the bank is exploring approaches to investments that encourage flexibility, robustness, and adaptive management.

ADB's practical experience thus far indicates that informational, institutional, and policy barriers often stand in the way. To get around these barriers, ADB has been investing in information, knowledge sharing, capacity building, and partnerships. At the same time, it has been developing and applying approaches to dealing with policy constraints. ADB has also strived to support countries with new financing approaches, such as disaster contingency financing.

Developing a vision for the future. ADB's new Strategy 2030 looks forward to a prosperous, inclusive, resilient, and sustainable Asia and the Pacific. Climate and disaster resilience is an operational priority under the strategy, and to help deliver this at scale, ADB has set the target of providing cumulative climate financing of $80 billion by 2030 from its own resources.

However, delivering this vision will require innovative operational approaches, and additional investment types and resources. ADB is therefore moving toward a holistic resilience approach, aimed at building resilience in the face of a wide range of shocks and stresses, and extending beyond physical infrastructure to include financial resilience, eco-based resilience, and social and institutional resilience. The advantages of such an approach are clear. It will deliver major economic benefits, but it will also build resilience at all levels, for individuals, households, communities, businesses, and nations.

Finally, to meet the anticipated investment needs for future infrastructure, as well as the changing profile of disaster and climate risk, Asia and the Pacific will need to unlock additional sources of funding, notably private investment. Together with its partners, ADB is developing innovative approaches to resilience financing and leveraging.

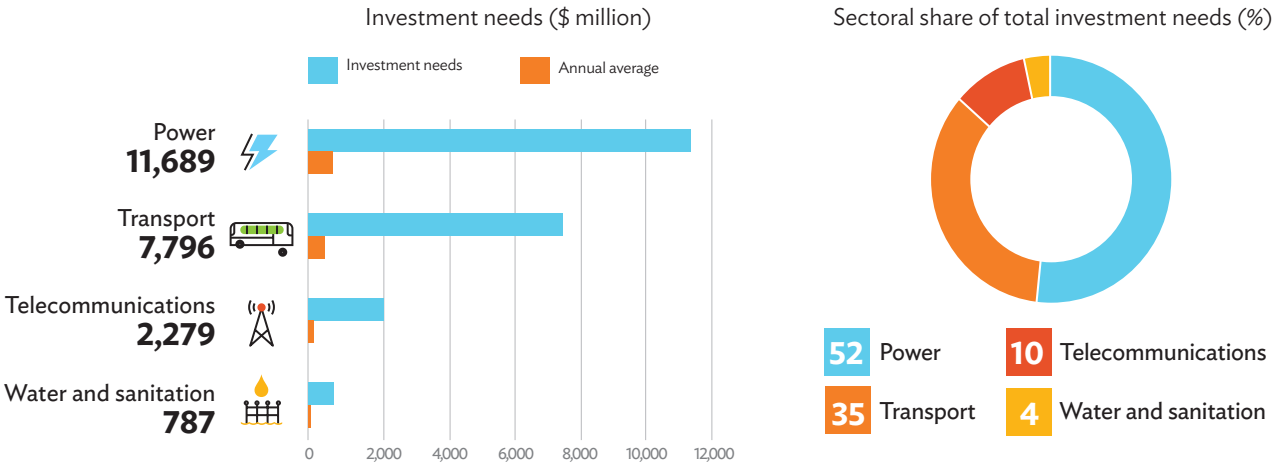
It is hoped that the insights shared in the paper will be of relevance and interest to partners in the international development and finance communities, and will provide inputs toward a future collaborative vision for building resilient infrastructure.

1. INTRODUCTION

1.1. Need for Significant Investment in Infrastructure in Asia and the Pacific

Asia and the Pacific has achieved dramatic progress in poverty reduction and economic growth over the past 50 years. Investment in infrastructure has had a key role in advancing this social and economic development, and the Asian Development Bank (ADB) has been pivotal in financing the region's development infrastructure. Infrastructure investment must increase significantly to maintain the momentum of economic growth in the region, to eradicate the remaining poverty, and to enable an appropriate response to climate change and disaster risk. According to a recent study (ADB 2017c), Asia and the Pacific will need to invest an additional $22.6 trillion in infrastructure, or $1.5 trillion per year, from 2016 to 2030, as shown in Figure 1. This amount does not include the additional investment in resilience needed to address future climate change.

Figure 1: Estimated Infrastructure Investment Needs, by Sector, in ADB's 45 Developing Member Countries, 2016–2030 ($ billion, in 2015 prices)



Source: adapted from Table 2, ADB, 2017a.

Over the same period, the region has experienced a significant increase in the impact of extreme weather events such as tropical cyclones, flooding, droughts, and heat waves. It has also endured major geophysical shocks, including earthquakes and tsunamis. While all countries come up against natural hazards, Asia and the Pacific is particularly affected: of the 10 countries facing the highest estimated disaster risk worldwide, seven are developing member countries (DMCs) of ADB.[1] These events result in significant loss of lives and high economic costs. Between 2008 and 2017 alone, disasters caused over 300,000 fatalities in ADB's DMCs, affected 1.56 billion people, and resulted in reported direct physical damage totaling $496 billion, equivalent to $136 million per day.[2] The impact of such events is also rising, and global losses from weather-related disasters and geophysical hazards in recent years are among the highest on record (Munich Re 2018; Swiss Re 2017).

Ongoing climate change could alter the frequency, intensity, extent, duration, and timing of extreme weather events, and is likely to result in unprecedented extremes (IPCC 2012; ADB 2017d). There is already evidence that human-induced global warming has made heavy precipitation events more frequent and intense globally, and increased the risk of other extremes in some regions (IPCC 2018; Hoegh-Guldberg et al. 2018). Climate change could also alter trends and induce shifts in the long-term average climate, with major impact on the region.

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[1] These are Bangladesh, Cambodia, the Philippines, Solomon Islands, Timor-Leste, Tonga, and Vanuatu, according to Kirch et al. (2017), although the authors point out that different risk indices place different countries in the top 10.

[2] Based on data drawn from EM-DAT: The International Disaster Database of the Office of US Foreign Disaster Assistance (OFDA) and the Centre for Research on the Epidemiology of Disasters (CRED), www.emdat.be, Université Catholique de Louvain, Brussels.

While the impact of climate change could affect every region, the impact projected for Asia and the Pacific is disproportionately high. Modeling studies estimate that climate change could impose high economic costs on both South Asia and the Pacific (ADB 2014a; ADB 2013a), and global studies expect South and Southeast Asia's economic costs to be double the global average by 2060 (OECD 2015b). This situation reflects the region's exceptionally high climate vulnerability, plus the increasing concentration of populations in cities that are in harm's way: 9 of the 16 countries globally assessed as being at "extreme risk" of climate change are ADB's DMCs.[3] In the long term, climate change presents an existential threat to at-risk countries such as small island developing states. Within the context of this paper, climate change will increase the risks from natural hazards to infrastructure, and also require additional infrastructure investment to address new shocks and stresses. Previous studies (e.g., World Bank 2010) have estimated the adaptation cost for the East Asia and Pacific region to be the highest among all regions; infrastructure will account for a large proportion of the cost. Deliberate action must be taken to build infrastructure for the region that is resilient to climate and disaster risks (Box 1).

Box 1: Resilience

Resilience is variously defined. Early definitions found in the disaster risk literature focus on the ability to bounce back after shocks, particularly from natural hazards such as earthquakes and drought. In recent years, the term has been extended to include resilience to the uncertainties of climate change, encompassing resilience to both shocks (extreme weather events) and stresses (slow-onset climate change). In this paper, resilience is defined as the capacity to resist, respond to, or recover from natural hazards and maintain essential infrastructure function, both now and over the medium and long term. These hazards include geophysical and weather-related hazards, with changes in weather extremes and climate trends reflecting changes in the Earth's climate and in exposure and vulnerability to those events and trends.

Source: Asian Development Bank.

1.2. ADB as an Early Mover in the Journey towards Building Resilient Infrastructure

Effectively reducing the impact of disasters on infrastructure—and addressing the additional threats from climate change—requires deliberate efforts to understand, assess, and manage those risks. For more than 2 decades, ADB has been among the leading institutions in Asia and the Pacific, as well as internationally, in understanding and addressing the potential impact of disaster and climate change. As shown in Figure 2, ADB's recent initiatives include a well- structured climate risk management framework, which is applied to all ADB investments. This has been complemented by carefully developed and strengthened institutional strategies, policies, and operational practices. ADB is recognized as a leader in systematically responding to climate and disaster risks in its operations, and has been widely consulted by other international financial institutions (IFIs), including multilateral development banks (MDBs).[4] Making the most of some of the early lessons learned in building resilience into investment operations, ADB made substantive contributions to a joint publication of the MDBs and the International Development Finance Club (IDFC) on lessons learned in tracking adaptation finance, which was launched at the 24th session of the Conference to the Parties of the United Nations Framework Convention on Climate Change (UNFCCC).[5] ADB, faced with the dual challenges of meeting infrastructure needs and effectively managing the growing risks of disaster loss and adverse climate change impact, is responding with even-greater focus and commitment, obligating itself to build on these early efforts to scale up its investments in resilient infrastructure in the coming decades.

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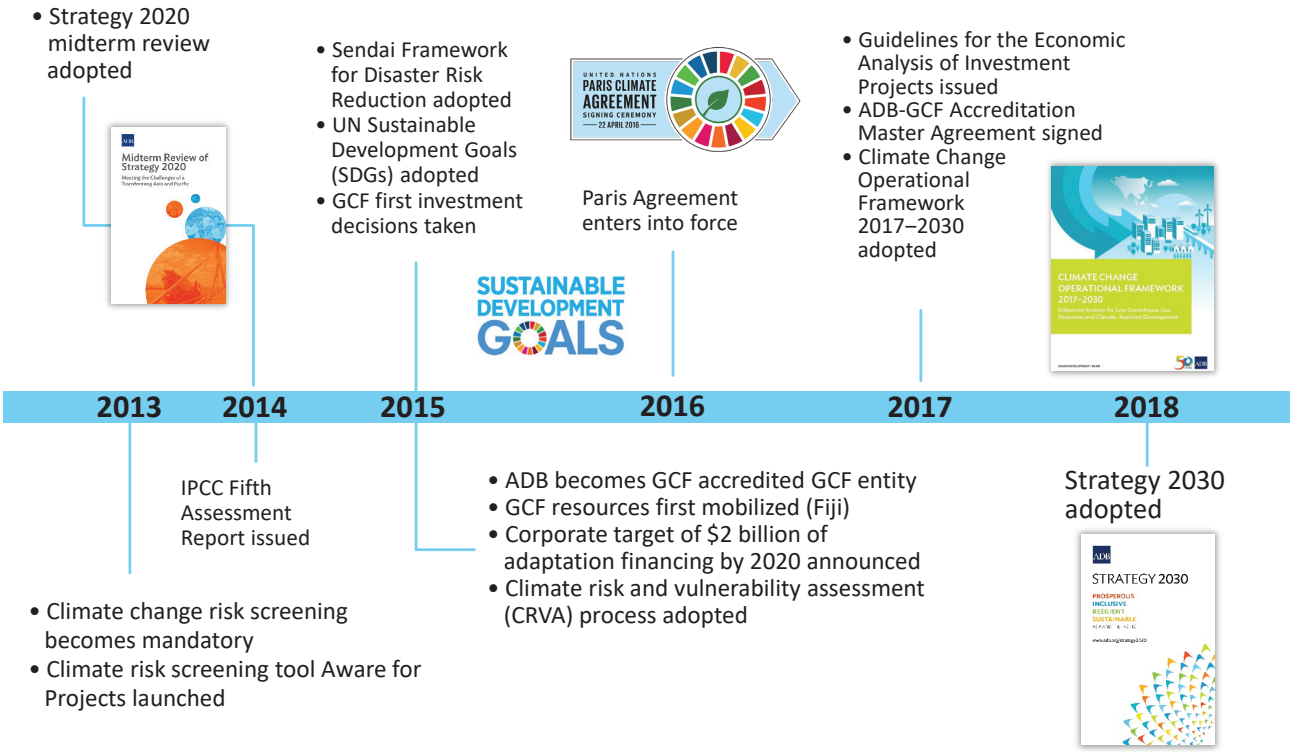
[3] The Climate Change Vulnerability Index (CCVI) (Maplecroft, https://www.maplecroft.com/about/news/ccvi.html) rates 16 countries, many of them in Asia, as being at "extreme risk": Bangladesh (ranked 1), India (2), Nepal (4), Philippines (6), Myanmar (10), Cambodia (12), Viet Nam (13), Thailand (14), and Pakistan (16). While different climate risk indices alter the order of the countries, all such indices identify high risks in Asia and the Pacific.

[4] For example, the Islamic Development Bank has requested technical advice and inputs to the development of its climate change strategy and climate risk management framework; the European Investment Bank and the Inter-American Development Bank have both followed ADB's lead in adopting climate risk screening; extensive technical engagement has taken place between ADB and the German state-owned development bank KfW and the French development agency Agence Française de Dévelopement (AFD), with KfW and AFD seeking ADB's advice on the establishment of a climate risk management framework and its supporting system.

[5] The full publication is available at https://www.idfc.org/wp-content/uploads/2018/12/mdb_idfc_lessonslearned-full-report.pdf.

Figure 2: Recent Milestones in ADB's Journey toward Building Disaster- and Climate-Resilient Infrastructure



ADB=Asian Development Bank, GCF=Green Climate Fund.
Source: Asian Development Bank.

1.3. Purpose of This Paper

At this critical juncture for ADB, this paper sets out ADB's experience and lessons learned so far regarding resilient infrastructure, and highlights opportunities for future partnerships and synergies, as well as new financing modalities. Insights shared here are expected to be of relevance and interest to partners in the development and finance communities regionally and internationally, as they deliver resilient infrastructure in the Asia and Pacific region, and beyond.

Following this introductory section, Section 2 synthesizes ADB's experience in building public infrastructure resilient to climate and disaster risks in three key areas: (i) corporate resilience strategy, policies, and approach (Section 2.1); (ii) financing of climate- and disaster-resilient public infrastructure through a wide range of structural and nonstructural resilience interventions (Section 2.2); and (iii) knowledge and partnerships (Section 2.3). Taking a forward-looking perspective, Section 3 identifies priority areas of work and opportunities to scale up investment in climate- and disaster-resilient infrastructure. Section 4 concludes the paper with a set of key messages highlighting the learning so far and opportunities to deliver climate- and disaster-resilient infrastructure at scale in Asia and the Pacific.

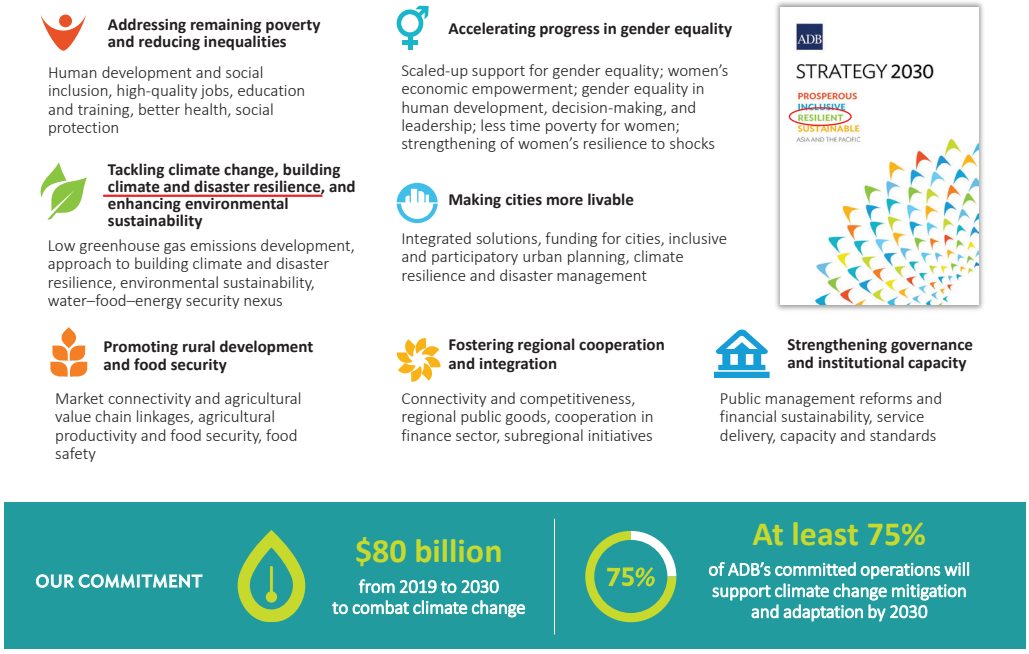
2. ADB EXPERIENCE IN BUILDING CLIMATE- AND DISASTER-RESILIENT PUBLIC INFRASTRUCTURE

2.1. ADB's Corporate Strategy, Policies, and Approach to Resilience

2.1.1. Building climate and disaster resilience: a corporate strategic priority

For the past 2 decades, ADB has been on a journey toward managing climate and disaster risks to infrastructure investments. With growing scientific and empirical evidence of disaster and climate risks, ADB's Strategy 2030 has set out a vision of a prosperous, inclusive, resilient, and sustainable Asia and the Pacific (ADB 2018b). The strategy identifies seven key operational priorities, one of which is "tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability." This calls for a major scale-up of investment in climate- and disaster-resilient infrastructure development. To support this effort, ADB has set ambitious targets: (i) at least 75% of the number of its committed operations (both sovereign and non- sovereign), based on a 3-year rolling average, will support climate change mitigation and adaptation by 2030; and (ii) climate finance from ADB's own resources will reach $80 billion for the period 2019–2030 (Figure 3). In addition, recognizing that action on climate change and disaster resilience can support the delivery of the other operational priorities in Strategy 2030,[6] ADB is moving to a more **holistic approach to resilience** (see Section 2.1.2 below).

Figure 3: Operational Priorities and Climate Change Targets in ADB's Strategy 2030



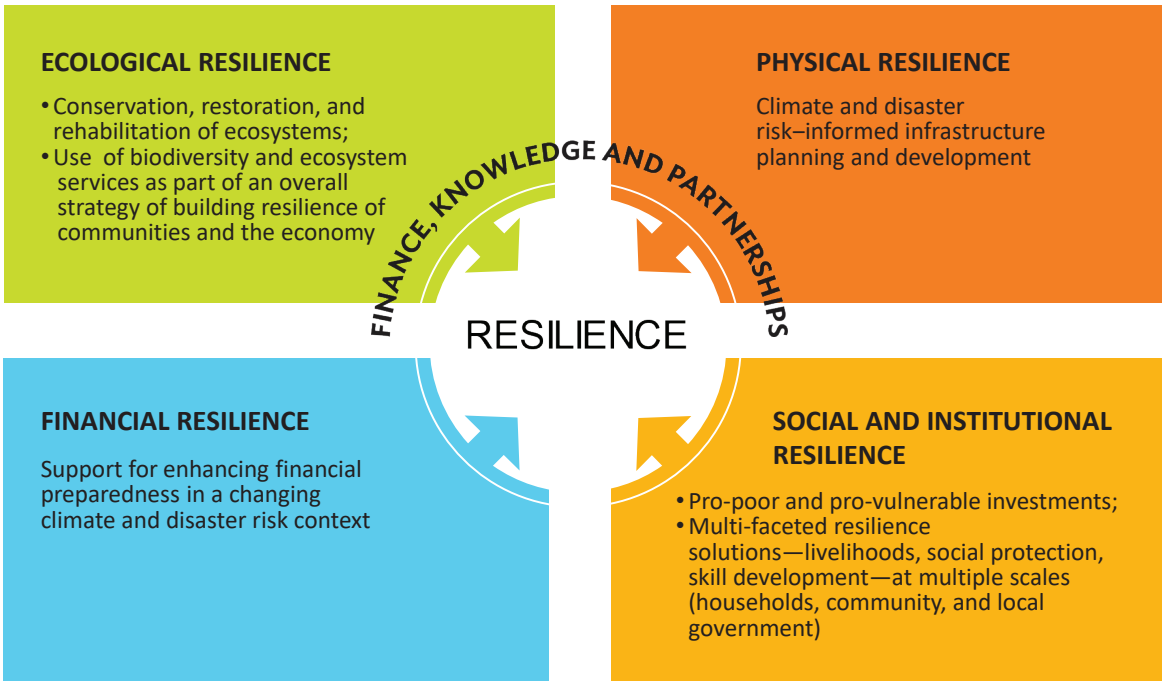
Source: Asian Development Bank.

2.1.2. ADB's holistic approach to resilience

To deliver the Strategy 2030 priority of building disaster and climate resilience while at the same time bringing about prosperous, inclusive, and sustainable development, a shift in focus is required. In response, ADB has advanced a **holistic resilience approach**. The aim is to build climate change and disaster resilience from four key perspectives: physical infrastructure resilience, financial resilience, eco-based resilience, and social and institutional resilience (Figure 4). Resilience will be delivered at all levels, to individuals, households, communities, businesses, and nations. This holistic approach, in the broader context of sustainable development, encompasses a number of priorities.

[6] The other key operational priorities are: addressing remaining poverty and reducing inequalities; accelerating progress in gender equality; making cities more livable; promoting rural development and food security; strengthening governance and institutional capacity; and fostering regional cooperation and integration.

Figure 4: A Holistic Approach to Resilience



Source: Asian Development Bank.

First, climate change and disaster risks should be taken into account when planning, designing, and building infrastructure projects (**physical resilience**). ADB has made major progress in this area, through the development and implementation of its project climate risk management (CRM) framework and other means (see Section 2.1.3 below), including the scale-up of infrastructure investments in disaster risk reduction and climate change adaptation.[7]

Second, there should be greater emphasis on biodiversity and ecosystem services as part of an overall strategy of helping people adapt to climate change and manage disaster risks (**eco-based resilience**). In this regard, ADB is supporting approaches such as coastal protection, nature- based river-basin flood risk management, erosion control, and urban water management.

Third, there should be a focus on the human and social dimensions of climate and disaster resilience (**social and institutional resilience**). This focus reflects the mutually reinforcing nature of poverty and vulnerability to climate change and natural hazards, and the disproportionately high impact of climate change and disasters on poor and vulnerable populations. ADB is initiating a project that will help prioritize investments with an explicit focus on the poor and vulnerable, to ensure that no one is left behind.

Finally, the financial management of residual disaster risk by countries, businesses, and communities (**financial resilience**) should be strong and effective, and should in turn support timely relief, early recovery, and reconstruction efforts and incorporate measures to build back better. With financial resilience in mind, ADB is supporting its DMCs in developing financing instruments such as disaster contingent financing and risk transfer mechanisms such as disaster insurance, and in enhancing post-disaster budget execution strategies.

[7] It is useful to distinguish between the two aspects of resilience in infrastructure investments. The first involves decisions relating to the location, design, construction, and operation of new infrastructure investments, to ensure that these are made more resilient. The second recognizes the need to increase investments in infrastructure for disaster risk reduction and climate change adaptation.

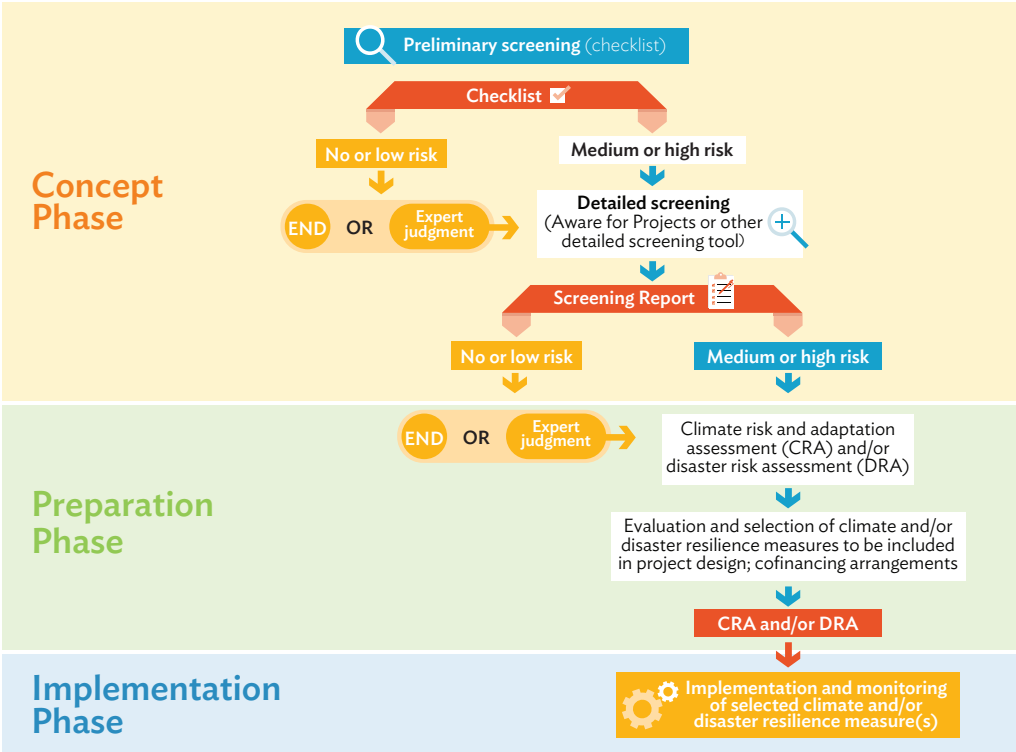
2.1.3. Climate risk management framework established by ADB

Since 2013, ADB has been implementing its CRM framework for projects. As illustrated in Figure 5, the CRM framework consists of the following steps:

- Context-sensitive climate risk screening at the concept development stage, to identify projects that may be at medium or high risk;
- Climate risk and adaptation assessment (CRA) in the preparation of projects that are assessed to be at risk;
- Identification and technical and economic evaluation of adaptation options in project design; and
- Monitoring and reporting of the assessed level of climate risk.

More recently, the level of adaptation finance has also been estimated and tracked by project teams, while disaster risk concerns, including near-term disaster risks and risks emanating from geophysical hazards, have been incorporated into the CRM framework.

Figure 5: Climate Risk Management Framework



Source: Asian Development Bank.

As part of the implementation of this framework, the assessed level of risk and the estimated adaptation finance are reported in key project documentation.[8] As illustrated in Figure 6, this involves close collaboration and coordination between operational teams and technical climate change teams. Project concept papers and key documentation are systematically reviewed to help ensure CRM quality and standards within projects. In addition, ongoing technical support is provided, through both in-house and external experts, to project teams, particularly for CRAs. Through ADB's internal Climate Change Fund (CCF),[9] financial support is also provided to project teams for carrying out CRAs

[8] A paragraph usually included in the "due diligence" section of the project's report and recommendation of the President to the Board of Directors sets out the climate risks identified, along with a brief description of the proposed strategy for addressing these risks. A linked document detailing the findings of the climate change assessment is also required for projects at medium or high risk, as determined through risk screening. If a more detailed climate risk assessment (CRA) has been conducted, it is often included in the report as a supplemental document.

[9] The CCF was established in 2008 to facilitate increased climate change investments in the DMCs. The CCF provides financing through four modalities: grant component of investments, stand-alone technical assistance, technical assistance piggybacked onto or linked to loans, and direct charge. It has four components: (i) adaptation; (ii) clean energy development; (iii) reduced emissions from deforestation and forest degradation, and improved land use management (REDD+ and land use); and (iv) climate finance readiness. As of June 2018, the CCF had received a total of $74 million in ADB financing. Of this amount, $22.7 million has been allocated to 48 adaptation projects.

or implementing adaptation measures. In addition, ADB has made notable strides in assisting its DMCs in securing external concessional and grant financing for resilient public infrastructure development (see Section 2.2 below).

To take stock of current practices in implementing the CRM framework, a comprehensive review has been carried out to assess the effectiveness of the current generation of CRAs in helping teams to design and implement more climate-resilient (fit-for-purpose) projects. Important insights have been gained through this exercise. While ADB's approach is judged to be relatively pragmatic and proportionate, compared with the frameworks developed by other MDBs, the review report notes that (i) there are opportunities to improve procedures and to strengthen the overall quality of project design to deliver climate-resilient results; (ii) economic analysis behind some publicly visible adaptation projects can be strengthened; (iii) bespoke guidance is needed to adapt investments in the coastal zone and built environment, given their high exposure and vulnerability to climate hazards; and (iv) there may also be scope for tracing the value added by CRAs to the eventual design and delivery of resilience investments through longitudinal analysis of completed projects. Efforts are already well under way to further improve the CRM framework and strengthen its implementation (see Section 3.1 below).

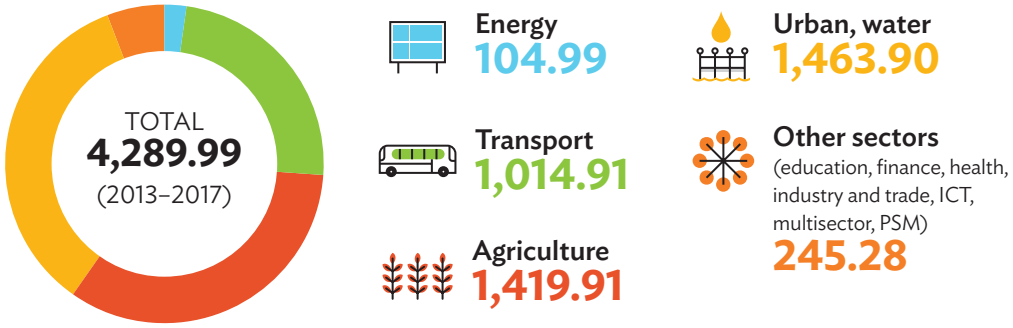
Figure 6: Collaboration and Coordination for Climate-Resilient Project Development at ADB

Source: Asian Development Bank.

2.2. Financing the Development of Climate- and Disaster-Resilient Public Infrastructure

Guided by its strategies and in response to the needs of its DMCs, ADB has been steadily increasing its financing for resilient infrastructure development, particularly in sectors that are more vulnerable to climate and disaster impact. As shown in Figure 7, during the 5-year period between 2013 and 2017, ADB invested a total of $4.29 billion in adaptation projects from its own resources, to improve the climate resilience of infrastructure investments, mostly in the urban, water development, transport, agriculture, and energy sectors.

Figure 7: Adaptation Finance from ADB's Own Resources ($ million)



ICT = information and communication technology, PSM = public sector management.
Source: Asian Development Bank.

Besides dedicating its own resources to investing in resilience, ADB has played a key role in the development of international climate finance architecture. With other MDBs, it operates a number of the most important climate funds that are focused on resilience, notably the Pilot Program for Climate Resilience under the Climate Investment Funds (CIF). It has also worked with the Green Climate Fund (GCF), leveraging concessional finance to support resilient infrastructure investment projects in some of the most vulnerable countries in the region. Moreover, ADB has sought cofinancing from bilateral donors to increase support for climate and disaster resilience investment in its DMCs, and established a set-aside program under the 12th replenishment of the Asian Development Fund (ADF 12) specifically for investment in disaster risk reduction, including the incremental costs involved in strengthening the resilience of transport, water, energy, and other infrastructure. Box 7 in Section 2.3 below gives details of some of these efforts.

The rest of this section presents a collection of resilience practices financed by ADB. These encompass investments aimed at strengthening the disaster and climate resilience of public infrastructure through a variety of approaches, taking into account the four dimensions of resilience (physical, financial, eco-based, and social and institutional), as discussed in Section 2.1.2 above.

2.2.1. Building climate- and disaster-resilient infrastructure

As discussed above, ADB has adopted a risk management approach to infrastructure planning and implementation, with risk screening and climate- and disaster-resilient design. For structural solutions, this approach has focused on two types of infrastructure investments:

- **Increasing resilience through investment**, with infrastructure designed for disaster risk reduction and climate change adaptation. While ADB has invested in disaster risk reduction for many years, in future years, this investment will be complemented with a greater focus on infrastructure for climate adaptation.
- **Increasing the resilience of infrastructure investments**, by making sure that disaster and climate risks are taken into account in the location, design, construction, and operation of planned infrastructure investments.

Infrastructure for strengthening climate and disaster resilience

Investing in disaster risk reduction (DRR) infrastructure, such as flood risk management infrastructure, has various benefits. Besides avoiding fatalities and injuries, it reduces damage and losses, and, by lowering risk, can create confidence to spur wider economic growth (Lloyd's 2018). Numerous reviews highlight the high economic benefit–cost ratios of DRR infrastructure investments (Mechler 2016; ECONADAPT 2016).

There are well-established methods of designing infrastructure for disaster risk reduction. These build on risk assessment methods, including hazard, exposure, and vulnerability analyses. ADB routinely applies these methods and uses these in the design of resilience projects across the region.

ADB has also been investing more in nature-based solutions, complementing hard-engineered structures for disaster risk reduction and climate resilience building (Shreve and Kelman 2014), in what is often referred to as the integration of green and gray infrastructure. Nature-based solutions make use of the ecosystem services that these natural habitats provide, including their regulating (resilience) functions, as well as their high co-benefits, such as positive environmental impact and livelihood opportunities. For example, mangroves are being used for coastal storm protection, and wetlands, for water-flow regulation and flood control. In Pingxiang, People's Republic of China, an ADB project is pilot-testing natural solutions (sponge cities) for dealing with the rising flood risk and with inadequacies in drainage infrastructure and wastewater treatment (ADB 2015b). The project integrates the use of forests, wetlands, green roofs, bio-retention, and surface water infiltration systems with more traditional gray solutions to deliver urban–rural flood risk management and ecological river management.

Integrating green and gray infrastructure. This project in Pingxiang, People's Republic of China, is helping protect floodplains, restore wetlands, and create wider green spaces along rivers (photo by ADB).

ADB is likewise investing in c**ommunity-based resilience infrastructure** for vulnerable groups, to ensure that no one is left behind. These projects, intended to develop social and institutional resilience, operate locally and on a small scale. For example, ADB is supporting the Government of Myanmar in strengthening community resilience by designing a project that delivers resilient community infrastructure and livelihood. Geographic areas are selected for the project following an analysis of multidimensional vulnerability, particularly exposure to natural hazards and the effects of climate change. The project's community-based development (CBD) approach encourages communities to design and implement tertiary infrastructure and associated livelihood support solutions that answer their needs, even as their institutional and organizational capacity, as well as that of government, is strengthened.

Enhancing the resilience of infrastructure

Natural hazards and climate change can affect infrastructure by destroying or damaging assets, increasing operation and maintenance costs, and reducing revenues and socioeconomic benefits (the wider benefits to the economy), thus affecting the financial and economic performance of projects. If infrastructure is made more resilient, this impact can be reduced.

ADB has been at the forefront of efforts to promote infrastructure resilience to disasters and to future climate change. **Climate proofing**, the term sometimes applied to the latter, seeks to ensure that infrastructure projects are designed to reduce or minimize the potential impact of climate change, including changes in the frequency and intensity of extreme weather events. It has been advanced through the implementation of the CRM framework set out in Section 2.1.3. Box 2 presents three infrastructure investment projects that incorporated climate and disaster resilience measures in their design.

Box 2: Making Infrastructure Investments Climate- and Disaster-Resilient

Enhancing engineering design specifications
The Central Mekong Delta Connectivity Project (ADB 2013b) is an $860 million investment project aimed at improving connectivity between the agricultural and agro-processing provinces of southern Viet Nam, on the one hand, and major national and regional markets, on the other. The project covers two major bridges (Cao Lanh and Vam Cong) that cross the Mekong River, and a 15-kilometer road connecting the two bridges. A study was done to assess the vulnerability of the project to climate change (and particularly to rising sea levels) and examine possible climate-proofing options. The study found that the embankments of the connecting road between the bridges were vulnerable to the projected increase in frequency and intensity of flooding, heightened by the rise in sea levels. Given these findings, one of the resilience project design features recommended was to raise the current design height of the road embankment by an extra 0.6 meters to deal with changes in the intensity of the 1-in-100-year flood event under a changing climate (ICEM 2012).

Building back better
ADB has focused on "build back better" design following the devastating earthquake in Nepal in April 2015 and major aftershocks. Under the Earthquake Emergency Assistance Project, ADB has assisted the government in accelerating recovery and reconstruction. Taking into account key lessons from the ability of school buildings constructed under the ADB-funded School Sector Program (ADB 2011b) to withstand the 7.8 magnitude tremor of the 2015 earthquake, project planners have incorporated in the rehabilitation and reconstruction of schools, roads, and settlements "build back better" design features, which strengthen both the disaster resilience and the future climate resilience of the infrastructure.

Allowing for flexibility in project design
ADB financed a $25 million project that rehabilitated and expanded the capacity of the port of Avatiu in the Cook Islands. The project widened the harbor entrance, undertook dredging to increase the depth of the channel, and enlarged the ship turning area. It also reconstructed and realigned the quay, repairing the adjacent wharf deck. Following the climate risk screening, the project modified the design to address the impact of future climate change. The project climate-proofed the wharf by replacing the existing structure, which was extremely vulnerable to wave action and forces, with one that included flexibility in design. This involved strengthening the pilings during construction to increase the load-bearing capacity, so that the wharf could be raised more easily in the future, if required because of faster-rising sea levels (ADB 2008).

Source: Asian Development Bank.

2.2.2. Other solutions for building climate- and disaster-resilient infrastructure

The focus above is on infrastructure—whether to enhance DRR or to make new infrastructure investments more resilient. However, a number of barriers often make it difficult to deliver resilience, because of information, governance, policy, and market failures (Cimato and Watkiss 2017). ADB has therefore been expanding its approach to address these issues and help scale up resilient infrastructure. Recent work on policy and finance are set out directly below, while information and capacity initiatives are discussed in Section 2.3.

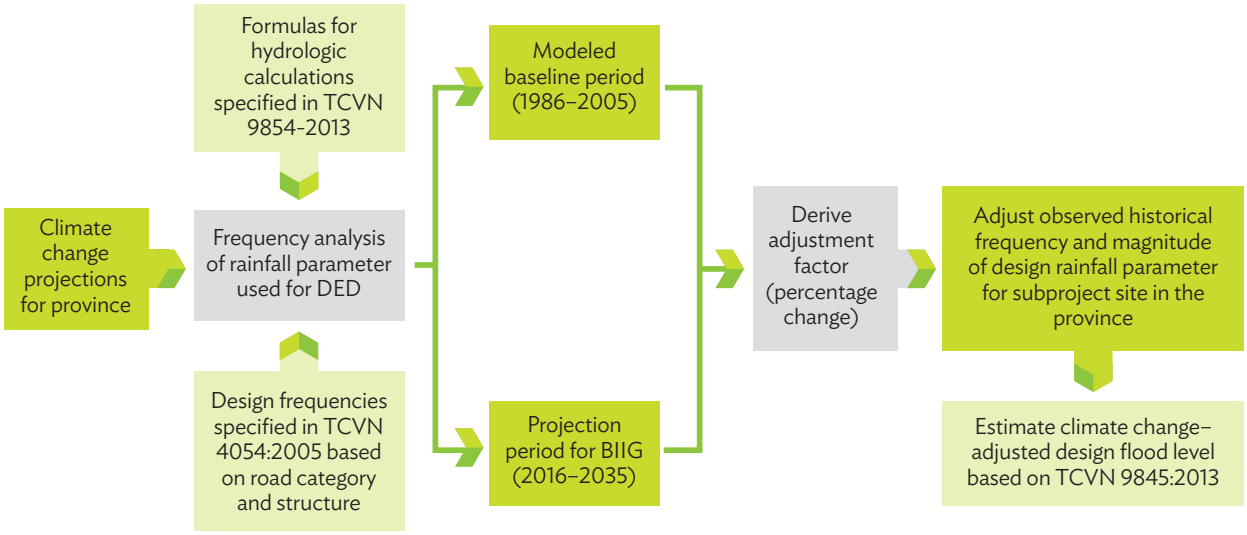
Policy and regulatory interventions

There can be institutional or policy barriers to building resilience features into infrastructure projects, especially when it comes to future climate change. One such example concerns engineering standards. Many countries have

existing engineering design standards, building codes, etc., that set mandatory safety and performance criteria for new construction, but these are typically based on historic weather extremes and do not take into account the changing climate and its consequences. These standards can act as a barrier to future climate resilience, because exceeding the current engineering standards (with higher levels of resilience) is not required under existing practice. The additional costs involved cannot always be justified, as the infrastructure already meets national performance criteria. This could be a barrier to implementing resilience measures identified at the project level.

This barrier can be addressed by working with countries to update their building codes and engineering design parameters to account for the changes in the characteristics of design extreme weather events (Wilby and Keenan 2012). ADB has been making efforts in this regard. For example, during the project preparation phase for the Basic Infrastructure for Inclusive Growth in the Northeastern Provinces Sector Project in Viet Nam, work was carried out to adjust the road design parameters to take into account changes in 1-in-25-year extreme rainfall events in the future (ADB 2017e). In line with the relevant government decree and regulations governing the road design standards (e.g., for Category 4 rural roads, 1-in-25 is defined as the design frequency, and there is a set of formulas specific to hydrologic calculations), analyses were undertaken to estimate the engineering design parameters under future climate conditions (ADB 2018a) (Figure 8). These enabled the updating or adjustment of the design parameters providing the design protection, as defined in the national design standard, in a changing climate. The analyses essentially entailed translating climate model projections of future climate into climate "safety margins" for standard variables such as heavy precipitation, wind speeds, wave heights, sea level rise, and river flow. Case studies have also been developed to show, step by step, how this approach can be applied in practice (ADB 2019b).

Figure 8: Adjustment of Hydrological Inputs to Road Design for Climate Change Risk Based on Extreme Value Analysis



BIIG = Basic Infrastructure for Inclusive Growth Project, DED = detailed engineering design, TCVN = Viet Nam's national system of standards.
Source: Asian Development Bank.

Financial solutions

ADB is working with its DMCs to strengthen their financial resilience to residual disaster risk. To help ensure timely and adequate flows of post-disaster funding, it is enhancing the associated financing arrangements. This support involves (i) analyzing needs and gaps in disaster risk and related relief, early recovery, and reconstruction funding; (ii) preparing comprehensive disaster risk financing strategies; (iii) developing and implementing disaster risk financing instruments; (iv) enhancing post-disaster budget execution strategies; and (v) positioning post-disaster financing instruments within a broader resilience framework.

For example, contingent financing for disasters established by ADB for five Pacific island countries—Cook Islands, Palau, Samoa, Tonga, and Tuvalu—gives these countries immediate access to liquidity following a disaster. The financing is provided through ADB's policy-based loan instrument. Under these projects, prior policy and monitorable actions focusing on measures to enhance resilience, including actions that directly or indirectly enhance infrastructure resilience, are agreed on. The achievement of the prior actions (completed before loan approval) enables eligibility to disburse funds. However, funds are disbursed, in part or in full, only in the event of a pre-agreed trigger event in the form of the declaration of a state of disaster in accordance with national legislation. These funds are then spent through the national budget. Tonga's $6 million contingent financing was disbursed in full 3 days after the country was struck by Tropical Cyclone Gita in February 2018, demonstrating the rapidly disbursing capability of this instrument. ADB is currently processing a new contingent disaster financing line for Tonga, as well as for four other countries in the Pacific.

There are also opportunities to support countries through enhanced insurance, which could provide an important source of leveraging to the private sector. Insurance is a risk-spreading mechanism. It can build resilience through more efficient allocation of resources to address high- impact, lower-frequency disasters, and is therefore an important part of a layered risk management strategy. It is also a complementary tool to adaptation for future climate change.[10] ADB has been investing in insurance, with a Pilot Project on Weather Index–Based Crop Insurance (WIBCI) in Bangladesh. This has shown the high demand for such products.

Opportunities exist as well for national risk-pooling facilities, including facilities at the macro-regional level. Along these lines, ADB has designed a city government disaster insurance pool for the Philippines to provide rapid post-disaster financing for early recovery following earthquakes and typhoons. The pool arrangement reduces premiums via risk diversification, economies of scale, and profit retention. Initial pool capital will be provided by the national government, which is expected to secure a sovereign loan from ADB for this purpose. The pool is due to be launched in 2020, scaling up relatively quickly.

ADB is also encouraging the use of financial risk management products to address the risks associated with investments in climate change mitigation and adaptation, and, in turn, to catalyze climate change financing from a broad range of sources, including the private sector. In this regard, it has collaborated with the German Federal Ministry for Economic Cooperation and Development (BMZ) to establish the Asia-Pacific Climate Finance Fund (ACliFF), This fund is configured to identify and support the implementation of innovative financial risk management approaches, products, and services that directly address (i) climate investment risk, including barriers for adopters and financiers, such as lack of familiarity with climate technologies, quality concerns regarding installation and maintenance, and other performance-related uncertainties; and (ii) extreme weather risk, improving resilience and reducing vulnerability to climate impact, particularly of poor and vulnerable communities, through such means as index-based flood or drought crop insurance, disaster risk insurance for microfinance institutions, and emergency liquidity facilities. Instruments supported through the fund include guarantees and insurance.

2.3. Leveraging Knowledge and Partnerships

As highlighted in its Strategy 2030, ADB prides itself on its being a financier and catalyzer of finance, as well as a knowledge provider and convener of partnerships (ADB 2018b). In support of this vision, ADB's Climate Change Operational Framework, 2017–2030, sets out plans to improve internal cooperation and coordination in knowledge and knowledge sharing (ADB 2017a). These include plans to develop a range of knowledge solutions for ADB's DMCs and strengthen partnerships and networks to deliver climate finance, foster policy dialogue, and assist in the implementation of Nationally Determined Contributions (NDCs) in its client countries. This section highlights some key knowledge activities under way that are aimed at enhancing the knowledge base and supporting climate-resilient investment decision making, and partnerships that have been helping catalyze action and finance for climate-resilient investment.

[10] Insurance spreads the financial risks of probabilistic extreme events, which might increase under climate change, but it cannot insure against climate change trends, as the risk-spreading mechanism breaks down and premiums become unaffordable in the event that those trends materialize. Increasing risks due to climate change will be factored into premiums by insurance providers, possibly making it harder to secure affordable insurance for more vulnerable individuals and places (UNEP 2018).

2.3.1. Supporting resilient investment decision making through knowledge development and learning

Access to information and knowledge, and availability of capacity, are fundamental to effective climate action. Decision makers, investors, and practitioners in infrastructure development require access to actionable information and knowledge that enables the formulation of policies and programs or projects supportive of their climate and development objectives. In addition, given the complex uncertainties associated with climate change and its impact, and thus the complex requirements for the effective management of climate and disaster risks, all infrastructure development stakeholders need to be assisted in strengthening their capacity to plan, develop, design, and implement climate-resilient policies and programs or projects.

ADB's efforts at knowledge provision in support of climate- and disaster-resilient investments have been focused on three main areas: data and information required for understanding climate and disaster risks; analytical methodologies, methods, and tools for assessing climate risks and adaptation interventions; and original analyses and insights that contribute to the broad knowledge base and understanding.

Among the data and information supplied by ADB is guidance on Disaster Risk Assessment for Project Preparation (ADB 2017b), provided as a basis for integrating disaster risk considerations in the design and implementation of individual projects. Included in this document are technical guidance and data sources for the analytical steps of disaster risk assessment, as well as information about disaster risk reduction interventions.

Similarly, it is recognized that climate change involves complex technical information that can act as a barrier to climate-resilient design. ADB has therefore been investing in climate change information to help address this, recognizing that such information is a public good. An example is the Regional Climate Projections Consortium and Data Facility in Asia and the Pacific.

Similarly, it is recognized that climate change involves complex technical information that can act as a barrier to climate-resilient design. ADB has therefore been investing in climate change information to help address this potential difficulty, recognizing that such information is a public good. The Regional Climate Projections Consortium and Data Facility in Asia and the Pacific, established under ADB technical assistance, is a response to requests from the DMCs for stronger integration of climate change into their development process and subsequently into climate change adaptation programs, projects, and their respective country operations business plans.[11] The technical assistance project was intended to (i) provide scientifically sound and decision-oriented climate data and projections; and (ii) enhance the technical capacity of the DMCs to generate, interpret, and apply climate information. The data facility is expected to lead to improved climate-resilient programs and project design in selected DMCs.

ADB has also retained a strong focus on knowledge products. These products are designed to serve either a general readership (as public goods) or program or project development practitioners (as operational support). Among other activities in this regard, ADB has been commissioning targeted research, documenting actual project experience as part of ongoing monitoring and learning efforts, implementing knowledge, and supporting technical assistance projects. Box 3 contains an indicative list of key knowledge products that ADB and its knowledge partners have developed in the area of climate and disaster risk management.

Moreover, mindful of the fact that merely making data, information, and knowledge available will not lead to the uptake or application of such knowledge products, ADB attaches equal importance to the dissemination of knowledge products and capacity building through knowledge events and dedicated training sessions. For example, two workshops presenting a nature-based approach to resilience were held in 2015 and 2017 as an ADB-wide collaborative effort. At these workshops, internationally renowned experts and practitioners in the subject, and representatives from ADB staff and DMC governments, shared insights and practical experience in international good practices, challenges, and opportunities for scaling up the application of nature-based solutions for building resilience. Such events have contributed to a growing portfolio of ADB investment projects embedding nature-based solutions in project design.

[11] The country partnership strategy (CPS) is ADB's primary platform for designing operations to deliver development results at the country level. ADB works with each DMC to map out a medium-term development strategy and a 3-year country operations business plan (COBP) for implementing the strategy.

As part of efforts to further strengthen ADB's project CRM framework, a staff training workshop was held to familiarize operations teams with a more "fit-for-purpose" CRM framework (see Box 4). Another key knowledge event worth highlighting is the 6th Asia-Pacific Climate Change Adaptation Forum in 2018 (see details in Box 5). The forum is the flagship event of the Asia Pacific Adaptation Network (APAN).

Box 3: Indicative List of ADB Knowledge Products in Support of Climate- and Disaster-Resilient Investments

GENERAL KNOWLEDGE PRODUCTS (PUBLIC GOODS)

Data, information, and compendium of technical resources

- (2017) The Regional Climate Consortium for Asia and the Pacific (RCCAP) Web Portal, which provides access to climate data, technical resources, and case studies (http://www.rccap.org)
- (2017) Climate Change Finance at ADB database, which provides details on investment in adaptation (as well as mitigation), at project level (https://data.adb.org/dataset/climate-change-financing-adb)
- (2018) Information Sources to Support ADB Climate Risk Assessments and Management: Technical Note (http://dx.doi.org/10.22617/TIM189600-2)
- (Forthcoming in 2019) Climate Risk Country Profile series

Analyses and insights

- (2009) Economics of Climate Change in Southeast Asia: A Regional Review (http://hdl.handle.net/11540/179)
- (2011) Accounting for Health Impacts of Climate Change (https://www.adb.org/sites/default/files/publication/28976/heath-impacts-climate-change.pdf)
- (2012) Addressing Climate Change and Migration in Asia and the Pacific (http://hdl.handle.net/11540/918)
- (2013) Investing in Resilience: Ensuring a Disaster-Resistant Future (http://hdl.handle.net/11540/89)
- (2013) Economics of Climate Change in East Asia (http://hdl.handle.net/11540/69)
- (2017) Meeting Asia's Infrastructure Needs (http://dx.doi.org/10.22617/FLS168388-2)
- (2017) A Region at Risk: The Human Dimensions of Climate Change in Asia and the Pacific (http://dx.doi.org/10.22617/TCS178839-2)
- (2017) Economics of Climate Change in Central and West Asia (adaptation component) (https://www.adb.org/sites/default/files/project-documents/44068/44068-012-tacr-en_0.pdf)
- (Forthcoming in 2019) Climate and Disaster Risks and Adaptation Investment Opportunities in the Asia-Pacific Region

PRACTICAL OPERATIONS GUIDANCE

General guidance and tools

- (2013) Aware for Projects (an online project climate and disaster risk screening tool)
- (2014) Climate Risk Management in ADB Projects (https://www.adb.org/sites/default/files/publication/148796/climate-risk-management-adb-projects.pdf)
- (2015) Economic Analysis of Climate-Proofing Investment Projects (https://www.adb.org/sites/default/files/publication/173454/economic-analysis-climate-proofing-projects.pdf)
- (2017) Natural Hazard Data: A Practical Guide (http://dx.doi.org/10.22617/TIM178692-2)
- (2017) Disaster Risk Management and Country Partnership Strategies: A Practical Guide (http://dx.doi.org/10.22617/TIM178691-2)
- (2017) Disaster Risk Assessment for Project Preparation: A Practical Guide (http://dx.doi.org/10.22617/TIM178893-2)
- (2018) Spatial Data Analysis Explorer (SPADE) (https://development.asia/explainer/using-spatial-cloud-computing-build-livable-cities)
- (Forthcoming in 2019) Guidance on Climate-Resilient Infrastructure Design by Using the Results of Extreme Rainfall Value Analysis

Sector-specific guidance

- (2011) Guidelines for Climate Proofing Investment in the Transport Sector: Road Infrastructure Projects (https://www.adb.org/sites/default/files/institutional-document/32772/files/guidelines-climate-proofing-roads.pdf)
- (2012) Guidelines for Climate Proofing Investment in Agriculture, Rural Development, and Food Security (https://www.adb.org/sites/default/files/institutional-document/33720/files/guidelines-climate-proofing-investment.pdf)
- (2013) Guidelines for Climate Proofing Investment in the Energy Sector (https://www.adb.org/sites/default/files/institutional-document/33896/files/guidelines-climate-proofing-investment-energy-sector.pdf)
- (2016) Guidelines for Climate Proofing Investment in the Water Sector: Water Supply and Sanitation (https://www.adb.org/sites/default/files/institutional-document/219646/guidelines-climate-proofing-water.pdf)

Source: Asian Development Bank.

Box 4: Project Climate Risk Management Workshop for ADB Staff

As part of the response to the results of a review of ADB's project climate risk management processes and practices, efforts have been made to reorient project-level climate risk and adaptation assessments so that they focus on evaluating the project objectives that could be most vulnerable to climate change. A training session was organized on 22–23 November 2018 to brief operations teams on this updated approach, using worked examples. The one-and-a-half-day session was structured around a series of five relatively self-contained modules. Proceedings of the training, including presentations and open discussions, were recorded on digital files and may be accessed by staff on demand as their schedules permit.

The five modules of the training are:

- **Module 1** – Understanding the project and focusing on what matters
- **Module 2** – Defining decision-led climate information and undertaking risk analysis
- **Module 3** – Identifying adaptation options in the context of uncertainty and timing
- **Module 4** – Conducting economic and financial analysis of risks and adaptation options
- **Module 5** – Developing funding proposals for implementing adaptation interventions

Source: Asian Development Bank.

Box 5: The 6th Asia-Pacific Adaptation Network Forum

The 6th Asia-Pacific Adaptation Network (APAN) Forum was held on 17–19 October 2018 at ADB Headquarters in Manila, Philippines (http://www.asiapacificadapt.net/adaptationforum2018/). The APAN Forum is the largest gathering of adaptation practitioners in the Asia and Pacific region. Co-hosted by the Government of Palau, the Philippine Climate Change Commission, and ADB, together with the APAN secretariat at UN Environment, the 6th APAN Forum had the overall theme "Enabling Resilience for All: Avoiding the Worst Impacts" and featured interactive sessions, panel discussions, and knowledge exchange. Under the broad theme of resilience, the forum was structured around four streams, focusing on the resilience of (i) human and social systems, (ii) ecological systems, (iii) industry and the built environment, and (iv) island communities. More than 1,000 scientists, government officials, representatives from civil society and businesses, and development partners from 60 countries participated in the 3-day deliberations. The urgent need for action was recognized, and a wide range of resilience solutions in action were shared and discussed throughout the forum sessions.

Source: Asian Development Bank.

2.3.2. Catalyzing action and investment through partnerships and networks

Successful action to build resilience to disaster risks and climate change impact will depend on strong partnerships and networks between development partners, and on work with, and support for the collaboration of, other subnational and non-state actors such as municipalities, private and state-owned companies, civil society groups, professional associations, and the academe, to name a few.

Knowledge and action networks

Working with knowledge partners, such as leading academic institutions and multilateral research organizations, has facilitated greater access to technical and scientific expertise in expanding knowledge of climate and disaster resilience and supporting resilient development decision making. Notable collaborations have included work with the following entities:

- The World Health Organization and the Food and Agriculture Organization, on the impact of climate change on health (ADB 2011a);
- The International Association of Insurance Supervisors, on strengthening the observance of international principles and standards for the supervision of insurance and reinsurance;
- The University of Adelaide, on migration (ADB 2012);
- The Potsdam Institute for Climate Impact Research, on the human dimensions of climate change (ADB 2017d);
- The UK Met Office and the Commonwealth Scientific and Industrial Research Organisation of Australia, on building resilience to extreme weather events, through the provision of science-based climate services and other means;
- The World Bank, on producing a set of climate and disaster risk country profiles for all ADB's DMCs (ADB 2019a);
- Various members of the CGIAR Consortium of International Agricultural Research Centers, on the development and field testing of a number of resource conservation technologies and drought- and flood-resistant crop varieties to support adaptation in the agriculture sector;
- The Government of Japan (Ministry of the Environment), on an ongoing basis, on a range of climate change adaptation and resilience initiatives, including the development of the Asia-Pacific Adaptation Information Platform (AP-PLAT); and
- Partners of APAN, notably on the organization of the APAN forums.

In addition, ADB participates actively in a range of multilateral partnerships and networks to promote the implementation of climate and disaster resilience policies and practices within various international policy frameworks and agreements, including the following:

- The joint Multilateral Development Banks (MDBs) declaration on aligning activities with the objectives of the Paris Agreement;[12]
- The joint MDB Working Group on Finance Tracking on the development of climate resilience metrics, with a view to providing a more effective measurement of the resilience outcome of investments;
- Other IFIs, to scale up support for developing countries and enable them to deliver on the 2030 development and climate agenda;
- The NDC Partnership, with other countries and international organizations committed to the ambitious implementation of Nationally Determined Contributions under the Paris Agreement and the 2030 Agenda for Sustainable Development; and
- The InsuResilience Global Partnership for Climate and Disaster Risk Finance and Insurance Solutions (see Box 6).

[12] The declaration was announced at the 24th Session of the Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC): https://www.ebrd.com/news/2018/mdbs-make-joint-declaration-on-climate-finance-alignment.html.

Box 6: InsuResilience Global Partnership for Climate and Disaster Risk Finance and Insurance Solutions

Launched at the 2017 UN Climate Conference in Bonn, the InsuResilience Global Partnership is a platform for inclusive collaboration, shared learning, and delivery on climate and disaster risk finance and insurance solutions, bringing together developing countries, development partners, the private sector, international organizations, and civil society. The vision of the partnership is to strengthen the resilience of developing countries and protect the lives and livelihoods of poor and vulnerable people against the impact of disasters. Its central objective is to enable more timely and reliable disaster response through the use of climate and disaster risk finance and insurance solutions. It builds on the collaboration between countries in the Group of Twenty (G20) and the Vulnerable Twenty Group (V20).

Hosted by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, a German development agency, on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), the InsuResilience Global Partnership has over 60 partners representing countries, civil society, international organizations, the private sector, and the academe.

Membership enables countries and stakeholders to play a role in shaping a growing community engaged in building financial protection against disasters. The partnership facilitates access to other key stakeholders to exchange experience, learn from one another, and drive impact together. Members can engage in working groups, access webinars, participate in the annual partnership forum, have their work featured in the partnership newsletter, and influence strategic decision making through potential invitations to join the High-Level Consultative Group.

Source: InsuResilience Global Partnership. http://www.insuresilience.org.

Partnerships for finance

Partnerships for finance have played an important role in expanding ADB's support for its DMCs in building resilience to climate and disaster risks. These financial partnerships are diverse in nature: they range from multilateral to bilateral, and from technical assistance projects and trust funds to investment programs. Box 7 presents some key multilateral funds that support ADB's climate resilience operations. In addition, a range of bilateral partnerships have also been leveraged to provide additional cofinancing for climate resilience initiatives, through ADB- administered special funds and facilities. These bilateral partnerships include the following:

- Integrated Disaster Risk Management Fund, Canadian Climate Fund for the Private Sector in Asia (I & II): Canada;
- Urban Climate Change Resilience Trust Fund: Switzerland, United Kingdom, United States, and the Rockefeller Foundation; and
- Japan Fund for Poverty Reduction: Japan.

Box 7: Major Multilateral Funds Supporting ADB's Climate Resilience Operations

Climate Investment Funds (CIFs). One of the largest sources of external climate finance accessed by ADB for its developing member countries (DMCs) is the Climate Investment Funds (CIF). Of particular relevance is the **Pilot Program for Climate Resilience** (PPCR), a $1.3 billion program of grants and concessional loans with the aim of achieving transformational change toward climate-resilient development in recipient countries. The PPCR supports developing countries and regions and has been instrumental in building ADB's portfolio of adaptation projects in the region. It assists governments in integrating climate resilience into strategic development planning across sectors and stakeholder groups, and provides finance to put these plans into action, pilot-testing innovative public and private sector solutions. ADB has been working with the PPCR, providing ADB finance (grants and concessionary loans) to recipient countries to help leverage PPCR funding. PPCR countries/regions include Bangladesh, Bhutan, Cambodia, the Kyrgyz Republic, Nepal, the Pacific region, Papua New Guinea, the Philippines, Samoa, Tajikistan, and Tonga.

Green Climate Fund. The Green Climate Fund (GCF) is now the largest source of international climate finance. ADB has been providing leveraging finance to its DMCs, to help them gain access to the fund. ADB was among the first organizations to be accredited as a multilateral implementing entity under the GCF, and the ADB project Fiji Urban Water Supply and Wastewater Management was one of the first-eight projects approved by the GCF Board in November 2015, securing $31 million in grant financing. This project established an important mode of collaboration between the GCF and ADB, through which the GCF provides grant finance to ensure the climate resilience of loan-financed development projects. The GCF co-chairs have encouraged ADB to develop a regional program for the Pacific to address climate action in these vulnerable countries. ADB is also examining other avenues of access to the GCF by its DMCs. ADB has received $265 million from the GCF, with six approved projects with adaptation components:

- Fiji: Urban Water Supply and Wastewater Management project ($31 million grant, approved in November 2015);
- Nauru: Climate Resilient Port project ($27 million grant, approved in October 2017);
- Kiribati: South Tarawa Water Supply project ($29 million grant, approved in October 2018);
- Tajikistan: Hydromet project ($5 million grant, approved in March 2018);
- Cambodia: Climate-Friendly Agribusiness Value Chains ($30 million grant, $10 million loan, approved in March 2018); and
- Mongolia: Ulaanbaatar Affordable Housing and Urban Renewal ($50 million grant and $95 million loan, approved in March 2018).

Global Environment Facility. ADB has been working closely with the Global Environment Facility (GEF) since the late 1990s, and since 2002 has served as one of 10 agencies with direct access to GEF resources. GEF provides incremental cofinancing that can be blended with ADB grants, loans, and other financial products to support the delivery of global environmental benefits. Since 2001, the GEF Council has approved approximately $120 million in grants for ADB-administered climate change projects.

Nordic Development Fund. The Nordic Development Fund (NDF) is a joint development finance institution of Denmark, Finland, Iceland, Norway, and Sweden. It provides technical assistance for climate risk management (CRM) capacity development, climate resilience for urban and rural infrastructure, and climate resilience in the health sector.

Source: Asian Development Bank. Climate Investment Funds. https://www.climateinvestmentfunds.org/. Global Environment Facility. https://www.thegef.org/. Green Climate Fund. https://www.greenclimate.fund/. Nordic Development Fund. https://www.ndf.fi/. https://www.ndf.fi/.

3. MOVING FORWARD: SCALING UP INVESTMENT IN CLIMATE- AND DISASTER-RESILIENT INFRASTRUCTURE IN ASIA AND THE PACIFIC

In light of the unprecedented investment needed for the region's infrastructure in the coming decades, and the growing risk of climate change impact, there is an urgent need to scale up investment in climate- and disaster-resilient infrastructure in Asia and the Pacific. Guided by its Climate Change Operational Framework 2017–2030 and Strategy 2030, and building on the efforts made and insights gained so far, ADB is well placed to step up action. To achieve the ambitious targets set out in the Strategy 2030, enhanced efforts will be made within three key areas: (i) knowledge and capacity, (ii) climate and disaster-resilient design practices, and (iii) financing.

3.1. Enhancing the Knowledge Base and Building Capacity

3.1.1. Strengthening the knowledge base

Despite the growing evidence regarding what works for infrastructure resilience, significant information gaps remain. ADB will continue to develop the knowledge base for disaster risk and climate model projections, through to the monitoring and evaluation of resilience results. A number of priorities are highlighted below.

A first priority is to improve knowledge of how structural and nonstructural resilience options perform, particularly the new focus on holistic approaches (integrating eco-based, financial, and social and institutional resilience), implemented individually or in portfolios.

As finance scales up, there will be an increasing need to make sure ADB's resources are used effectively, efficiently, and equitably. A greater focus on the economics of resilience is required. This includes the need to strengthen the economic appraisal of investments, and to build the evidence base for the costs and benefits of resilience. ADB also needs to take greater account of how best to build economics into decision making under uncertainty, noting the need for pragmatic approaches that fit within the ADB project cycle, and the available time and resources. A priority in this regard is learning more about how to program resilience, with more focus on the barriers that exist and how these can be overcome. This will help to maximize leveraging with country and private sector finance, to deliver at scale. A related issue is strengthening the downstream implementation of resilience, contributing to the delivery of iterative adaptive management, as well as increasing monitoring and evaluation.

There is also increasing recognition of the risk of cascading impact of disasters on unaffected sectors and geographies (Dawson et al. 2016). Infrastructure services such as heating, lighting, mobility, and sanitation are essential for modern society and are increasingly reliant on each other (e.g., for power, control, and access, and through information and communication technology, or ICT, links). Damage to infrastructure in one sector or geography can therefore lead to important indirect (cascading) economic losses via interdependent infrastructure linkages, such as the consequences of damage to electricity supply or transmission infrastructure on ICT and transport networks. Failure to make infrastructure investments resilient can therefore have important knock-on effects, affecting wider productivity and services. Of particular concern are systemic risks due to extreme weather events, which can lead to the breakdown of infrastructure networks and critical services such as electricity, water supply, health, and emergency services. The main interdependencies and interconnectivities are centered on energy, water, transport, and ICT. These cascading risks require a **systems approach**—considering infrastructure resilience as part of a wider system. A more integrated approach to assessing climate and disaster risk must be taken, exploring the consequences of damage beyond impact on the functioning of the individual assets alone.

Ongoing and future technical assistance support could have a key role in addressing these critical gaps in knowledge. In addition, systematically documenting experiences from a growing diversity of resilience practices and sharing them widely could contribute significantly to the ongoing knowledge development and learning. Further, new knowledge partnerships could be leveraged to facilitate learning and coproduction of knowledge, particularly in areas where critical gaps in knowledge and skills remain.

3.1.2. Building capacity

Designing and delivering infrastructure for a changing and uncertain climate will require new skills and abilities in a diversity of fields. This represents a particular challenge within Asia and the Pacific, where access to significant financial resources or cutting-edge expertise is not yet readily available. Formal education, as well as technical and vocational education and training, in this field creates a foundation, and requires the development of appropriate curricula and modules for training professionals. Learning by doing is important, given the need to both move forward and to develop better approaches to the challenges of addressing multiple hazards and the uncertainty associated with climate change. But it is also very important to learn from others, to avoid reinventing the wheel and to accelerate learning.

3.2. Strengthening and Promoting the Use of Climate- and Disaster-Resilient Infrastructure Design

3.2.1. Extending CRM upstream and downstream from project development

ADB has recently taken stock of its experience with climate risk management and resilient investments in the past 5 years, as part of a program of continuous review and improvement, and has identified priorities for improving the CRM framework and the integration of resilience. Among the areas identified for improvement are: (i) the provision of climate services, including climate data and information relevant to resilience investment decision making; (ii) economic analysis of resilience interventions in investment projects; and (iii) professional development and training for key project partners. In response, ADB has started updating its guidance on CRAs, to enhance the climate-proofing of new investments, improve the guidance on climate risk screening and resilient project design, and provide more targeted supporting material and case studies. These activities will help improve the resilience of the existing and new project portfolio, and ensure that infrastructure investments are climate-smart.

ADB also recognizes that over the next decade, climate change could have increasingly large impact, which would start to threaten economic growth and development in Asia. ADB will have to shift from its current focus on resilient investments (climate proofing) toward investments that target climate change impact, as is already happening in the context of disaster risk management. This can be seen as a change in the ADB climate portfolio, from building the "resilience of investments" to financing "resilience through investments" for client countries.

An important step underpinning both current and future investments is a move upstream for CRM, enabling the identification of early entry points for the introduction of climate- and disaster-resilient infrastructure development into country partnership strategies and country operations business plans. This move is to be made in recognition of the strong economic rationale for resilience at the strategic level, and the greater impact that can be achieved if resilience is integrated earlier in the investment project cycle. A series of supporting upstream actions, to scale up the development and redevelopment of resilient infrastructure, are already under way.

3.2.2. Developing and promoting climate-resilient infrastructure design

For the systematic enhancement of infrastructure resilience, building codes and engineering design standards must be updated to take a changing climate into account. The development and revision of standards is typically a slow process. While much climate science has advanced to appropriate levels to inform decisions, a central challenge is to bring this progress to engineering practice. Analyses and insights gained from adjusting engineering design parameters at the project level indicate that there is scope for multilateral institutions like ADB to play a key role in further developing and promoting the application of engineering design practices informed by climate and disaster risk considerations. For example, much potential exists for mainstreaming resilience into infrastructure development through the codevelopment and adoption of updated design standards during the preparation of sectoral master plans.

Beyond the MDBs, there is likely to be an important role for standards and norms in creating incentives for private sector involvement in initiatives to develop infrastructure resilience, as well as for the uptake of resilience in commercial bank lending. ADB is contributing to this debate by collaborating with international standard-setting bodies and in the emerging development of industry standards and guidance on climate resilience.

3.3. Providing Increased Financing

3.3.1. Importance of the public sector in setting standards and creating incentives

In spite of the upward trend in reported investment in climate change adaptation and resilience, there remains a notable gap between what is required to deliver resilient infrastructure and what is currently available in the region. To deliver climate- and disaster-resilient infrastructure at scale, significant finance, both public and private, must be mobilized. Governments could use their purchasing power to increase the resilience of their investments. For example, national or subnational authorities could promote "code-plus" compliance in government-funded infrastructure investments, where standards exceed the minimum life safety requirements of local building codes. There is also a need, particularly in the short term, to accelerate investments in resilience by offering incentives, e.g., resilience tax credits, loans, or grants.

3.3.2. Key role of private sector engagement in mobilizing resilience financing at scale

A linchpin of infrastructure resilience financing efforts will, however, be the engagement of the private sector, which is responsible for constructing and managing a significant share of the region's infrastructure. To expand resources beyond existing funds and modalities, ADB will have to make use of its own funds to leverage private sector finance.

Catalyzing private sector CRM and investment: Importance of climate-related financial disclosure by businesses

An obvious first priority is raising awareness of climate risks so that these issues become integrated into financial markets, commercial lending, due diligence, and company risk analysis. Incentives for financial markets to price in climate change risks have increased recently with initiatives such as the Task Force on Climate-related Financial Disclosures (TCFD).[13] The initial focus has been on the risk of stranded assets because of mitigation policy and carbon taxation—the risk that investments in fossil fuel reserves or generation plants, for instance, are unable to earn an economic return sometime before the end of their originally assumed economic life (McGlade and Ekins 2015; Mercure et al. 2018).[14] However, there is increasing recognition of the need to assess and disclose physical climate impact risks in investment proposals. Disclosure will promote the integration of climate risks into private sector decisions.[15]

Public finance can also be used to address barriers to private sector investment, creating enabling conditions for the private sector through awareness-raising and information campaigns, technical assistance support, and demonstration studies to address risk perceptions. In this regard, ADB will continue to support and collaborate with initiatives that promote awareness and create the enabling environments needed to make private financing available for investment in climate- and disaster-resilient infrastructure, including contributing to initiatives under the TCFD.

Unlocking private sector finance through insurance

Beyond such initiatives, insurance could be crucial in unlocking major private sector funding to enhance resilience, with ADB having a role, as planned under the Asia-Pacific Climate Finance Fund (ACliFF). The insurance industry has developed risk coverage solutions for the entire infrastructure life cycle, and there are major opportunities for new technologies and innovations, and for the implementation of market-based solutions. In 2017, insurance and reinsurance companies worldwide paid out $144 billion to cover insured losses resulting from natural disasters and man-made catastrophes—the highest amount ever. The industry has also helped to develop the catastrophe bond (cat bond) market. More than $30 billion outstanding bonds have been issued so far; the first public sector cat bonds triggered payouts in 2016 and 2017. Yet these instruments remain significantly underused in ADB's DMCs.

Novel approaches could involve a range of other insurance instruments (Lloyd's 2018), such as insurance-linked loan packages (infrastructure loans with built-in insurance), resilience impact bonds (pay-for-performance contracts), and resilience bonds (risk-linked financing mechanisms similar to cat bonds, which take resilience measures into account).

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[13] Established by the G20's Financial Stability Board at the end of 2015 (https://www.fsb-tcfd.org).

[14] Recent analysis of the risks of stranded assets has been undertaken in Asia (Caldecott, McCarten, and Triantafyllidis 2018).

[15] Although it will have some unintended consequences, notably by drawing attention to the higher climate risks in the most vulnerable countries, and potentially reducing investment or increasing the cost of borrowing—something that is already starting to happen, as evidenced by the addition of basis points for developing countries (Buhr et al. 2018).

Leveraging public–private partnerships

In concerns related to infrastructure development and financing, and the operation and maintenance of projects to improve their economic and physical performance, public–private partnerships (PPPs) are becoming part of the broader solution. Their role in enhancing the disaster and climate resilience of infrastructure investments is therefore an important one. The public sector has typically borne the disaster risks so far. However, a major challenge in the design and preparation of private sector bids for climate-resilient infrastructure is the extent to which climate risk is transferred to the private sector. This issue will be particularly acute for PPPs, because of the highly prescriptive performance payment regimes that apply to them. For example, private operators required by the contracting authority to add an earthquake rider to their fire insurance policy would have difficulty continuing in a PPP project because of reduced profitability. Hence, while they recognize the need for insurance, its regional characteristics and availability would figure prominently in the bidding decisions of those private operators.

One area of focus is making the knowledge and information needed to improve resilience available to the private sector. ADB has provided strong advisory and financial support for conventional project development, including PPP approaches. In collaboration with others, ADB has developed and funded comprehensive online project preparation platforms, such as SOURCE, which supports "best-in-class" preparation of PPP infrastructure projects. Launched globally in 2016, SOURCE addresses the difficulties arising from lack of standardization in project prioritization, planning, preparation, and execution, and helps to strengthen the project pipeline of sustainable PPP infrastructure projects. Resilience is not specifically addressed in project stocktaking at present; adding questions related to resilience would be one way of increasing awareness and uptake.

Consideration of resilience is also at an early stage in PPPs. Climate risks are not considered explicitly or allocated to a specific party in a standard PPP risk allocation framework. However, introducing a robust, well-defined, and fair PPP scheme that allocates risk appropriately and addresses the expectations of the investment community could help resilient infrastructure projects demonstrate that they can generate attractive and secure returns.

Policy and institutional reforms are required as well in PPP frameworks. These might include the need to translate the public sector's climate risk screening and resilience building processes (and lessons) for use in private sector and PPP projects; to enhance land use planning policies and enforce them to avoid investment in high-risk locations; and to use higher design standards. Insurance protection might also be included in national infrastructure policy.

Exploring other innovative financing instruments

Finally, given the projected increase in natural hazards under climate change, there are some other innovative financing instruments that could help. Green and climate bonds are among these instruments. While these bonds have primarily had a mitigation or refinancing focus, climate adaptation bonds have potential. In August 2016, in line with its Green Bond Program, ADB raised $1.3 billion to help finance climate change mitigation and adaptation projects by issuing dual- tranche 3-year and 10-year green bonds, following its inaugural green bond issue in March 2015. Further, in March 2016, ADB supported the issuance of the region's first certified climate bond for a geothermal power project in the Philippines. This was also the first-ever climate bond issued for a single project in an emerging market. In addition, concerted efforts are being made, by ratings agencies (e.g., S&P Global Ratings 2017) and initiatives such as the CBI and the World Bank Group,[16] to develop standards for climate resilience investments with a view to increasing the issuance of green and climate bonds to finance climate resilience projects. ADB has been actively engaged in these efforts, and is exploring opportunities arising from these emerging developments for innovative resilience financing.

[16] An expert group has been established under the CBI to develop a set of standards for certifying adaptation and resilience projects, to be launched later in 2019.

4. CONCLUSION

There is urgent impetus for prioritizing, planning, designing, executing, and scaling up investments in climate- and disaster-resilient infrastructure in Asia and the Pacific. This paper set out insights from the recent experience of the Asian Development Bank in this area, and showed how these lessons are being considered in the development of a new vision for climate- and disaster-resilient infrastructure investment in the region.

"Tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability"—one of seven operational priorities in ADB's new Strategy 2030—calls for a major scaling up of investment in climate- and disaster-resilient infrastructure. ADB has pledged $80 billion in cumulative climate finance from its own resources by 2030. This pledge reflects ADB's recognition of the support that action on climate change and disaster resilience will provide for the delivery of other operational priorities under Strategy 2030, as well as the Sustainable Development Goals.

However, given the volume of the required regional investment in infrastructure, and the level of disaster and climate change risk in Asia and the Pacific, scaling up ADB's current approach alone is unlikely to deliver on the strategy's aspirations. New types of investments, innovative financial instruments, and greater leveraging of private sector finance are needed.

This paper first looked at ADB's experience thus far and drew lessons regarding what works, identifying good practice that can be scaled up. Insights into the programming and financing of disaster risk reduction, and the need to broaden investment to include different types of infrastructure (gray and green), were presented. Changes that should be made in the climate risk management framework, to enhance resilience in future infrastructure investments and improve adaptive management, strengthen economic appraisal, and address information, policy, and institutional barriers, were pointed out. Alongside these, the paper defined the role of new financial instruments, building on current pilot projects and applying these instruments at scale with contingent credit, insurance, and risk transfer mechanisms. The paper then considered additional actions that could facilitate the delivery of resilient infrastructure in the region, including actions that ADB could do differently. A number of priorities were laid out.

First, there is already a move in ADB to develop a holistic resilience approach, with the potential to deliver much greater impact. This will involve building resilience to a wide range of shocks and stresses—extending beyond physical infrastructure to include financial, eco-based, and social and institutional resilience—and at all levels, among individuals, households, communities, businesses, and countries. Major economic benefits will accrue as a result.

Second, there are opportunities to explore, pilot-test, and scale up new and innovative financial approaches and mechanisms for resilience. These will build on ADB's recent success in contingent financing and the deployment of national disaster risk management funds, and could also extend to other national initiatives. Risk transfer at multiple scales (from national to local) using insurance will be among the mechanisms explored.

Third and lastly, there is a set of forward-looking activities centered on leveraging private sector finance, to unlock investment in climate- and disaster-resilient infrastructure. These activities could include advisory and financial support to build resilience in project development, along with the strengthening of the climate risk management and resilience-building processes. Disaster and climate risk sharing and risk transfer in public–private partnerships, as well as enhanced insurance and reinsurance, could also be among the activities, as could dialogue and the development of capital market solutions.

Complementing all of the above areas, ADB will continue to support and collaborate with initiatives that promote awareness and create an enabling environment for communities, countries, development partners, financial institutions, and the private sector to build climate- and disaster- resilient infrastructure in the region and beyond.

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Building Resilient Infrastructure for the Future
Background paper for the G20 Climate Sustainability Working Group

This working paper was prepared to provide inputs for discussions at the Group of Twenty (G20) Climate Sustainability Working Group meeting in Tokyo, Japan, in February 2019. It provides insights on the experience of and lessons learned by the Asian Development Bank on resilient infrastructure and highlights opportunities for future partnerships and synergies with partners in the development and finance communities regionally and internationally. It also explores new financing modalities for building resilient infrastructure.

About the Asian Development Bank

ADB is committed to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific, while sustaining its efforts to eradicate extreme poverty. Established in 1966, it is owned by 68 members —49 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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