



# Technical Assistance Report

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Project Number: 49158-001  
Research and Development Technical Assistance (RDTA)  
September 2016

## Building Climate Change Resilience in Asia's Critical Infrastructure

This document is being disclosed to the public in accordance with ADB's Public Communications Policy 2011.

Asian Development Bank

### ABBREVIATIONS

ADB	–	Asian Development Bank
DMC	–	developing member country
DRM	–	disaster risk management
GIS	–	geographic information system
NEX–GDDP	–	National Aeronautics and Space Administration Earth Exchange Global Daily Downscaled Projections
SDCD	–	Climate Change and Disaster Risk Management Division
TA	–	technical assistance

### NOTE

In this report, "\$" refers to US dollars.

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## CONTENTS

	<b>Page</b>
RESEARCH AND DEVELOPMENT TECHNICAL ASSISTANCE AT A GLANCE	
I. INTRODUCTION	1
II. ISSUES	1
III. THE RESEARCH AND DEVELOPMENT TECHNICAL ASSISTANCE	2
A. Impact and Outcome	2
B. Methodology and Key Activities	2
C. Cost and Financing	4
D. Implementation Arrangements	4
IV. THE PRESIDENT'S DECISION	5
APPENDIXES	
1. Design and Monitoring Framework	6
2. Cost Estimates and Financing Plan	8
3. Outline Terms of Reference for Consultants	9

## RESEARCH AND DEVELOPMENT TECHNICAL ASSISTANCE AT A GLANCE

<b>1. Basic Data</b>		<b>Project Number: 49158-001</b>	
<b>Project Name</b>	Building Climate Change Resilience in Asia's Critical Infrastructure	<b>Department /Division</b>	SDCC/SDCD
<b>Country</b>	REG	<b>Executing Agency</b>	Asian Development Bank
<b>2. Sector</b>	<b>Subsector(s)</b>	<b>ADB Financing (\$ million)</b>	
✓ Water and other urban infrastructure and services	Urban flood protection		0.25
	Urban water supply		0.25
Energy	Conventional energy generation		0.25
	Large hydropower generation		0.25
Transport	Road transport (non-urban)		0.25
	Urban public transport		0.25
<b>Total</b>			<b>1.50</b>
<b>3. Strategic Agenda</b>	<b>Subcomponents</b>	<b>Climate Change Information</b>	
Inclusive economic growth (IEG)	Pillar 2: Access to economic opportunities, including jobs, made more inclusive	Climate Change impact on the Project	Low
<b>4. Drivers of Change</b>	<b>Components</b>	<b>Gender Equity and Mainstreaming</b>	
Governance and capacity development (GCD)	Client relations, network, and partnership development to partnership driver of change	No gender elements (NGE)	✓
Knowledge solutions (KNS)	Knowledge sharing activities		
Partnerships (PAR)	International finance institutions (IFI) Official cofinancing		
<b>5. Poverty and SDG Targeting</b>	<b>Location Impact</b>		
Project directly targets poverty and SDGs	No	Regional	High
<b>6. TA Category:</b>	B		
<b>7. Safeguard Categorization</b>	Not Applicable		
<b>8. Financing</b>			
<b>Modality and Sources</b>		<b>Amount (\$ million)</b>	
<b>ADB</b>		<b>1.50</b>	
Research and development technical assistance: Technical Assistance Special Fund		1.50	
<b>Cofinancing</b>		<b>0.00</b>	
None		0.00	
<b>Counterpart</b>		<b>0.00</b>	
None		0.00	
<b>Total</b>		<b>1.50</b>	
<b>9. Effective Development Cooperation</b>			
Use of country procurement systems	No		
Use of country public financial management systems	No		

## I. INTRODUCTION

1. This Asian Development Bank (ADB) regional technical assistance (TA) project is designed to increase knowledge, promote innovation and good practice, and identify priorities for scaling up climate-resilient investments in South Asia and Southeast Asia. The TA will improve understanding of climate risks to critical infrastructure<sup>1</sup> in the region and identify investment priorities to increase resilience to climate change. The project will focus on the road and water transport, conventional energy generation and hydropower, and water supply and flood protection subsectors. The TA will also assess technology, policy, and knowledge solutions to the need to make infrastructure investments more resilient to the effects of climate change. These will include engineering measures; ecosystem-based adaptation; technology; and financial delivery, insurance, and risk transfer mechanisms.<sup>2</sup>

## II. ISSUES

2. Emerging markets and low-income countries continue to need large investments in infrastructure to remove constraints on growth; create job opportunities; respond to urbanization pressures; and meet crucial development, inclusion, and environmental goals. In 2009, ADB estimated that an infrastructure investment of \$8 trillion would be required during 2010–2020 to maintain current levels of growth in Asia.<sup>3</sup> Other estimates have put the need at \$5.36 trillion a year by 2025, or almost 60% of the overall global infrastructure investment requirements. The bulk of these needs are in energy, water, and transport infrastructure.<sup>4</sup>

3. Infrastructure for transport and communications, energy generation and transmission, and the supply of water and sanitation are critical for development. These types of infrastructure usually have long service lives, which renders both the region's existing infrastructure stocks and its future infrastructure investments vulnerable to changes in climate conditions that may take place in the near and medium terms. One of five overarching reasons for concern cited by the fifth assessment report of the Intergovernmental Panel on Climate Change in 2014 was the existence of systemic risks “due to extreme weather events leading to breakdown of infrastructure networks and critical services such as electricity, water supply, and health and emergency services.”<sup>5</sup>

4. Due to its vast and varied geography, Asia and the Pacific will experience most of the projected climate change impacts, particularly the increased risk of submergence, coastal flooding, and coastal erosion in coastal systems and low-lying areas. By 2060, 729 million–983 million people are projected to be living in low-elevation coastal zones in Asia.<sup>6</sup> Inland ports, seaports, roads, rail, airports, energy and water supply, energy distribution, storm water and sewerage systems, and other infrastructure assets are highly sensitive to slow-onset climate change. This includes gradual increases in air temperature and sea levels. They are equally

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<sup>1</sup> The United Nations Office for Disaster Risk Reduction defines critical facilities as “the primary physical structures, technical facilities and systems which are socially, economically or operationally essential to the functioning of a society or community, both in routine circumstances and in the extreme circumstances of an emergency.” [http://www.unisdr.org/files/7817\\_UNISDRTerminologyEnglish.pdf](http://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf)

<sup>2</sup> The TA first appeared in the business opportunities section of the ADB website on 27 September 2016.

<sup>3</sup> ADB and ADB Institute. 2009. *Infrastructure for a Seamless Asia*. Tokyo.

<sup>4</sup> PricewaterhouseCoopers. 2014. *Capital Project and Infrastructure Spending: Outlook to 2025*. Delaware.

<sup>5</sup> Intergovernmental Panel on Climate Change. 2014. *Climate Change 2014 Impacts, Adaptation, and Vulnerability: Summary for Policymakers (Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change)*. Cambridge, UK; and New York: Cambridge University Press. p. 13.

<sup>6</sup> B. Neumann et. al. 2015. Future Coastal Population Growth and Exposure to Sea-Level Rise and Coastal Flooding—A Global Assessment. *PLoS ONE*. 10(3): e0118571. doi:10.1371/journal.pone.0118571.

vulnerable to such extreme events as flooding from heavy precipitation, high winds, and storm surges. A detailed understanding of the impacts of climate change on critical infrastructure is of great importance, since it can inform the continued and sustainable development of ADB's developing member countries (DMCs) in South Asia and Southeast Asia.

### III. THE RESEARCH AND DEVELOPMENT TECHNICAL ASSISTANCE

5. The TA will help to address emerging development challenges identified in the 2014 midterm review of ADB's Strategy 2020 and meet an ADB priority to scale-up support for climate-resilient development in its DMCs.<sup>7</sup> The TA will expand ADB's knowledge dialogue with the DMCs for country programming. It will provide information for use in planning development programs and investment strategies in the target DMCs, and adaptation solutions by sector and investment needs. The TA will also inform ADB's preparation of a long-term strategic framework to succeed Strategy 2020. The TA will support ADB's efforts to scale up climate-resilient investments in the region and meet its annual climate adaptation finance target of \$2 billion by 2020. By the TA project's completion, ADB and DMCs will have a fuller understanding of the actions and innovation needed to make critical infrastructure in South Asia and Southeast Asia more resilient to climate change.

#### A. Impact and Outcome

6. The impact will be scaled-up support for effective climate change adaptation. The outcome will be knowledge base on climate change risks to critical infrastructure enhanced in South Asia and Southeast Asia.

#### B. Methodology and Key Activities

7. The TA will build on the current understanding of climate change impacts on the economy in South Asia and Southeast Asia, ongoing TA projects supported by ADB,<sup>8</sup> and the knowledge already available to help developing countries transition on to a low-carbon, climate-resilient development path.<sup>9</sup>

8. The TA will have three outputs.

9. **Output 1: Critical infrastructure in the energy, transport, and water sectors in South Asia and Southeast Asia identified.** The TA will identify critical existing infrastructure assets and facilities in the energy, transport, and water sectors in South Asia and Southeast Asia. The TA will develop a methodology and criteria for establishing which infrastructure is critical to the social and economic development of the targeted subregions and/or is part of key economic corridors. A framework for analyzing the long-term performance of interdependent infrastructure systems will be developed. The approach developed will be based on methodologies already tested in the region and globally. These include (i) dependence matrixes that represent the probability of each asset in a complex system being seriously disrupted directly or indirectly by propagation effects of the disruption of another asset; and (ii) consequence criteria, such as the concentration of people who would be affected by disruption,

<sup>7</sup> ADB. 2014. *Midterm Review of Strategy 2020: Meeting the Challenges of a Transforming Asia and Pacific*. Manila.

<sup>8</sup> Such as ADB. 2014. *Technical Assistance for Financing Low-Carbon, Climate-Resilient Urban Infrastructure in Asia and the Pacific*. Manila; ADB. 2015. *Technical Assistance for Establishing the Future Cities Program in the Asia and Pacific Region*. Manila; and the work funded by the Urban Climate Change Resilience Trust Fund.

<sup>9</sup> For example, regarding power sectors in South Asia and Southeast Asia: World Resources Institute. 2010. *Over Heating: Financial Risks from Water Constraints on Power Generation in Asia*. Washington, DC.

the type and number of sectors that would shut down, the debilitating consequences for other sectors and the whole country's economy, and recovery time.

10. ADB will select the methodology to be used with the support of TA consultants and centers of excellence during the first 5 months of TA implementation. The TA will then identify critical infrastructure in the energy, transport, and water sectors for the target subregions, focusing on the road and water transport, conventional energy generation and hydropower, and water supply and flood protection subsectors in both rural and urban areas. The assets identified will be cataloged through databases, simulation modeling, and visualization tools. A road map of planned infrastructure will be developed based on demand for infrastructure services and relevant national development strategies.

11. **Output 2: Climate change risks to existing and planned critical infrastructure in the energy, transport, and water sectors in South Asia and Southeast Asia assessed.** The TA will assess climate change risks in South Asia and Southeast Asia to existing and planned critical infrastructure in the energy, transport, and water sectors. Based on this analysis, the project will select pilot areas in the two regions for further study. The pilot areas will cover a mix of countries with medium and low income, and have a variety of geographical characteristics, including coastal, mountainous, and other topographies. The TA will undertake a detailed, spatially explicit assessment of climate change risks, including weather-induced disaster risks, to existing and planned critical infrastructure assets, as well as the services they provide and the communities they serve.

12. The assessment will consider climate change scenarios for three time periods—2016–2030, 2030–2050, and 2050–2080—drawing on existing climate and projections data sets, including the United States' National Aeronautics and Space Administration's Earth Exchange Global Daily Downscaled Projections.<sup>10</sup> Climate scenarios will be used to assess climate change impacts on the critical infrastructure the project identifies and the services and populations these assets serve. The TA will analyze the risks that will arise if interdependent infrastructure networks fail due to current climate variability and future climate change. Existing assessment tools and models will be used to the greatest extent possible. Climate change information will be made available electronically on an interactive geographic information system (GIS) platform that will be developed under the TA and will target climate change adaptation practitioners in DMCs that are involved in the design and/or climate risk assessment of infrastructure projects.<sup>11</sup>

13. **Output 3: Policy, financial priorities, adaptation options, and climate resilience standards for the target sectors identified.** The TA will identify policy, financial priorities, adaptation options, and climate resilience standards for the target sectors. The TA will formulate recommendations on governance, policy, regulatory, and financial measures that can be deployed to strengthen climate resilience and avoid leaving critical infrastructure assets and their services vulnerable to the long-term effects of climate change. Based on the project's assessment of the vulnerability of existing infrastructure and available information, the TA will examine approaches to climate risk management, including those developed by ADB and other financial institutions, and potential engineering and non-engineering adaptation measures. The TA will examine engineering solutions and adaptation measures based on high technology that

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<sup>10</sup> National Aeronautics and Space Administration (NASA), Climate Data Service. NASA Earth Exchange Global Daily Downscaled Projections. <https://cds.nccs.nasa.gov/nex-gddp/>

<sup>11</sup> Under this TA, the NEX-GDDP data format will be converted into more user-friendly formats available through the interactive GIS platform.

can be developed to reduce climate risks. Non-engineering measures will include ecosystem-based adaptation that can be retrofitted to existing infrastructure and applied to the design of new infrastructure to increase resilience to climate change and disaster risk. The project will also develop performance indicators that can be used to measure the effectiveness of climate-resilient infrastructure designs.

14. The project will develop climate resilience design metrics or standards for the target sectors, taking into account the different needs and national circumstances and work done by other institutions to design resilient infrastructure.<sup>12</sup> Case studies will be produced for three DMCs to demonstrate the benefits of investing in climate resilience. The studies will examine investments in the transport, energy and water sectors that can be considered for the three countries' programming and investment pipelines. The three countries will be selected from among the pilot DMCs within the geographical areas identified under output 1. They will be highly vulnerable to the effects of climate change and be at three different levels of development—i.e., a low-income DMC, a low-income country transitioning to middle-income status, and a middle-income DMC.

15. The TA will conduct outreach activities, such as workshops and knowledge dialogues, to raise the awareness of stakeholders in the region of the vulnerability of critical infrastructure to climate change and to inform them of the TA findings. The TA will increase the capacity of decision makers from the public and private sectors not only to anticipate climate risk, but also to appreciate the net benefits of investing in climate resilience. A knowledge product on design features for climate-proofing infrastructure in the region and summaries for policy makers will be produced and disseminated at regional and international events.

16. Several risks exist to the achievement of the intended outputs and outcome. Knowledge generated by the TA may not be transferred to the relevant line ministries in targeted DMCs. The availability of detailed data on critical infrastructure may be limited. The impact modeling at an appropriate scale of resolution may require more time to complete and absorb more TA resources than planned. ADB will mitigate these by facilitating knowledge dissemination in targeted DMCs, sourcing expert knowledge on infrastructure assets and facilities from the region, allocating sufficient budget and contingency for infrastructure mapping and impact modeling, and disseminating knowledge to relevant government stakeholders in the selected DMCs.

### **C. Cost and Financing**

17. The TA is estimated to cost \$1,500,000, of which \$1,340,000 will be financed on a grant basis by ADB's Technical Assistance Special Fund (TASF-others) and \$160,000 by ADB's Technical Assistance Special Fund (TASF-V).

### **D. Implementation Arrangements**

18. ADB will be the executing agency.<sup>13</sup> The Climate Change and Disaster Risk Management Division of the Sustainable Development and Climate Change Department will be the implementing agency and will administer the TA and coordinate with ADB's South Asia

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<sup>12</sup> This includes work on climate adaptation standards being undertaken by the International Organization for Standardization and the standard for sustainable and resilient infrastructure developed by the Global Infrastructure Basel Foundation.

<sup>13</sup> Prior to commencing or financing of any proposed activities under the TA, a no-objection in writing will be obtained from each selected DMC.



Department, Southeast Asia Department, Private Sector Operations Department, and relevant resident missions. The Climate Change and Disaster Risk Management Division will work closely with the transport, energy, urban, and water sector groups to generate practical and operation-oriented solutions. A TA coordination unit of representatives from relevant operations departments and sector groups may be established to help implement the TA activities.

19. Centers of excellence will provide the core research and practices that will underpin the achievement of outputs 1 and 2. Researchers from the United Kingdom Met Office may provide (i) an assessment of historical climate and climate model projections for South Asia and Southeast Asia, including an assessment of the adequacy of available data and coherence across models; (ii) identification of climate change hot spots in South Asia and Southeast Asia where the magnitude and/or rate of climate change are likely to create challenges to the physical integrity and/or performance of critical infrastructure; and (iii) input to the development of geo-spatial coverage, summarizing climate-related risks that can serve as a basis for national and sector planning.<sup>14</sup>

20. The Infrastructure Transitions Research Consortium of the University of Oxford and other centers of excellence may (i) develop criteria to identify and catalog critical infrastructure in South Asia and Southeast Asia; (ii) develop a case study to demonstrate how the developed methodologies on critical infrastructure can be effectively applied in a national infrastructure assessment; (iii) identify relevant concepts, models, and tools needed to identify and test robust, sustainable, and climate-resilient infrastructure design standards for the provision of national infrastructure; and (iv) provide input to the assessment of policy, financial, engineering, and non-engineering solutions to increase the climate resilience of infrastructure in South Asia and Southeast Asia. Other centers of excellence may provide key resources and international best practices. Procedures for knowledge partnerships will be aligned with ADB guidelines currently under development. Input from utilities and facility managers from the public and private sectors will be sought through such existing mechanisms as the ADB Water Operators Partnerships Program to facilitate knowledge sharing and ensure that the climate-resilient solutions identified by the TA are operational and replicable.

21. The TA will require 23 person-months of international and 36 person-months of national consultant inputs. Consultants will be engaged as individuals and as firms following ADB's Guidelines on the Use of Consultants (2013, as amended from time to time). The project will require expertise in multiple areas, including (i) climate risk and vulnerability assessment; (ii) climate risk management; (iii) adaptation planning; (iv) disaster risk management; (v) water, energy, and transport infrastructure planning and systems; (vi) climate change economics; and (vii) GIS. TA disbursements will be made following ADB's *Technical Assistance Disbursement Handbook* (2010, as amended from time to time). The TA will be implemented from October 2016 to June 2019.

#### IV. THE PRESIDENT'S DECISION

22. The President, acting under the authority delegated by the Board, has approved the provision of technical assistance not exceeding the equivalent of \$1,500,000 on a grant basis for Building Climate Change Resilience in Asia's Critical Infrastructure, and hereby reports this action to the Board.

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<sup>14</sup> ADB and the United Kingdom Met Office signed a letter of intent in February 2015 to strengthen cooperation in helping developing countries in Asia and the Pacific to address climate vulnerability and in promoting climate-resilient development.

### DESIGN AND MONITORING FRAMEWORK

Impact the TA is Aligned with			
Scaled-up support for effective climate change adaptation (Midterm Review of Strategy 2020) <sup>a</sup>			
Results Chain	Performance Indicators with Targets and Baselines	Data Sources and Reporting	Risks
<p><b>Outcome</b></p> <p>Knowledge base of climate change risks to critical infrastructure enhanced in South Asia and Southeast Asia</p>	<p>a. At least two projects addressing vulnerabilities identified by the TA are included in selected DMCs' pipelines by 2019</p> <p>b. ADB investments in climate-resilient infrastructure<sup>b</sup> in selected regions increased by 50% by 2019 (2015 baseline: \$256.36 million)<sup>c</sup></p>	<p>a. Country programming strategies and project documents</p> <p>b. 2020 ADB annual report; 2020 joint report on MDB climate finance tracking</p>	<p>Knowledge generated by the TA is not transferred to the relevant line ministries in targeted DMCs</p>
<p><b>Outputs</b></p> <p>1. Critical infrastructure in the energy, transport, and water sectors in South Asia and Southeast Asia identified</p> <p>2. Climate change risks to existing and planned critical infrastructure in the energy, transport, and water sectors in South Asia and Southeast Asia assessed</p> <p>3. Policy, financial priorities, adaptation options, and climate resilience standards for the target sectors identified</p>	<p>By 2019:</p> <p>1a. Technical working paper on the methodology to identify critical infrastructure finalized</p> <p>1b. Road map of infrastructure planned for each target area produced</p> <p>2a. Technical paper on climate change vulnerability of critical infrastructure published in peer-reviewed journal</p> <p>2b. GIS web-based information platform produced</p> <p>3a. Interregional policy dialogue conducted</p> <p>3b. Three case studies completed</p> <p>3c. Climate resilience metrics for transport, energy, and water sectors developed</p> <p>3d. Knowledge product on measures to build climate resilience in Asia's infrastructure published</p>	<p>1a–b. TA progress reports</p> <p>2a. Peer-reviewed article in international journal</p> <p>2b. TA progress reports</p> <p>3a. TA progress reports</p> <p>3b–d. Knowledge product</p>	<p>Availability of detailed data on critical infrastructure is limited</p> <p>Impact modeling at an appropriate scale of resolution requires more time to complete and absorbs more resources than originally planned</p>

<b>Key Activities with Milestones</b>
<p><b>1 Critical infrastructure in the energy, transport, and water sectors in South Asia and Southeast Asia identified</b></p> <p>1.1 Agree on criteria and methodological approach for the analysis of critical infrastructure (Q1 2017)</p> <p>1.2 Explore partnerships with centers of excellence, the private sector, utilities, and facility managers (Q2 2017)</p> <p>1.3 Carry out a scoping activity to identify target countries and/or target geographical areas, and produce a universal list of existing critical infrastructure in South Asia and Southeast Asia (Q2 2017)</p> <p>1.4 Analyze relevant sector development plans and policy (Q2 2017)</p> <p>1.5 Hold national and regional consultations (Q3 2017)</p> <p>1.6 Produce a draft technical report on critical infrastructure (Q3 2017)</p> <p><b>2 Climate change risks to existing and planned critical infrastructure assessed in the energy, transport, and water sectors in South Asia and Southeast Asia</b></p> <p>2.1 Conduct a study on climate variability and climate change on selected regions as an input to the vulnerability assessment of critical infrastructure (Q3 2017)</p> <p>2.2 Conduct national and regional dialogues (Q4 2017)</p> <p>2.3 Peer review a draft final report on the climate vulnerability of critical infrastructure (Q4 2017)</p> <p>2.4 Develop a GIS-based platform for the visualization of critical infrastructure (Q4 2017)</p> <p><b>3 Policy, financial resources, adaptation options, and climate resilience standards identified</b></p> <p>3.1 Conduct a preliminary study to analyze an existing policy and regulatory framework that can support climate change adaptation (Q4 2017)</p> <p>3.2 Conduct consultations and policy dialogues (Q1 2018)</p> <p>3.3 Select one candidate case study for each sector of a target DMC to demonstrate the benefits of investing in climate resilience (Q1 2018)</p> <p>3.4 Produce an assessment of viable policy, regulatory, financial, and adaptation measures aimed at increasing the climate resilience of existing and planned infrastructure (Q2 2018)</p> <p>3.5 Develop standards for climate resilience in infrastructure in the transport, energy, and water sectors (Q3 2018)</p> <p>3.6 Produce a knowledge product and a summary for policy makers on the climate vulnerability of critical infrastructure and recommendations for investing in climate resilience (Q4 2018)</p> <p>3.7 Launch knowledge product (Q1 2019)</p>
<p><b>Inputs</b></p> <p>ADB: \$1,500,000</p>
<p><b>Assumptions for Partner Financing</b></p> <p>Not applicable</p>

ADB = Asian Development Bank, DMC = developing member country, GIS = geographic information system, MDB = multilateral development bank, Q = quarter, TA = technical assistance.

<sup>a</sup> ADB. 2014. *Midterm Review of Strategy 2020: Meeting the Challenges of a Transforming Asia and Pacific*. Manila.

<sup>b</sup> Climate-resilient infrastructure is infrastructure that is designed, built, and operated to withstand climate change impacts and contribute to a community's ability to cope with climate change, based on the best available knowledge on climate variability and change at the time of design.

<sup>c</sup> ADB's 2015 internal financing for climate change adaptation in South Asia and Southeast Asia.

Source: Asian Development Bank.

**COST ESTIMATES AND FINANCING PLAN**  
(\$'000)

Item	Amount
<b>Asian Development Bank<sup>a</sup></b>	
1. Consultants	
a. Remuneration and per diem	
i. International consultants	439.8
ii. National consultants	104.5
b. International and local travel	96.0
c. Reports and communications	50.0
2. Centers of excellence (non-consulting services) <sup>b</sup>	552.8
3. Training, seminars, and conferences <sup>c</sup>	
a. Regional workshop	50.0
b. Policy dialogue	50.0
4. Surveys	36.9
5. Miscellaneous administration <sup>d</sup> and support costs <sup>e</sup>	40.0
6. Representative for contract negotiations	5.0
7. Contingencies	75.0
<b>Total</b>	<b>1,500.0</b>

<sup>a</sup> Financed by the Asian Development Bank's Technical Assistance Special Fund (TASF-V and TASF-others).

<sup>b</sup> The centers of excellence will provide research and best practice knowledge under existing knowledge and/or new partnership agreements with the Asian Development Bank.

<sup>c</sup> Includes one regional workshop and one policy dialogue, which are expected to take place in the target countries and be attended by 40 participants.

<sup>d</sup> Includes honorarium and travel costs for resource persons and facilitators, participants' travel costs, staff travel costs as resource persons and/or speakers, and logistical costs, including software.

<sup>e</sup> Includes representation expenses following Asian Development Bank (Budget, Personnel and Management Systems Department; and Strategy and Policy Department). 2013. Use of Bank Resources: Regional Technical Assistance and Technical Assistance vs. Internal Administrative Expenses Budget. Memorandum. 26 June (internal).

Source: Asian Development Bank estimates.

## OUTLINE TERMS OF REFERENCE FOR CONSULTANTS

### A. General

1. The Asian Development Bank (ADB) will administer the technical assistance (TA) for Building Climate Change Resilience in Asia's Critical Infrastructure. The TA project will assess the climate vulnerability of critical infrastructure in the transport, energy, and water sectors in South Asia and Southeast Asia and identify adaptation solutions. The project will provide a platform for coordinating with centers of excellence, knowledge partners, the private sector, and consultants. ADB, through the Climate Change and Disaster Risk Management Division (SDCD) of its Sustainable Development and Climate Change Department, will be the executing agency. SDCD will lead overall implementation in collaboration with ADB's South Asia Department, Southeast Asia Department, and Private Sector Operations Department, as well as its energy, transport, urban, and water sector groups.

2. The centers of excellence will provide the core research and practices to underpin (i) the development of a methodology and identification of critical infrastructure in the transport, energy, and water sectors in South Asia and Southeast Asia (output 1); and (ii) the assessment of the vulnerability of the identified critical infrastructure to climate variability and change (output 2). While ADB has established partnership agreements with some centers of excellence, other partnerships may be established for the purpose of this TA. Procedures for knowledge partnerships will be aligned with ADB guidelines currently under development. The centers of excellence will deliver analytical and operationally relevant inputs based on agreed work plans formulated during the first 3 months of the TA implementation and as needed later on.

3. The TA will require 23 person-months of international and 36 person-months of national consultant inputs to coordinate and manage the technical assessments. The consultants should have strong technical expertise and a track record in adapting infrastructure systems in the transport, energy, and water sectors to climate variability and change; geographic information systems; and climate change economics. The consultants will play a critical facilitation role and should have skills to adequately use resources and engage with centers of excellence, the private sector, and partner agencies.

### B. International Consultants

4. **Senior climate change adaptation and disaster risk management consultant and team leader** (10 person-months, intermittent). The consultant will be responsible for the overall coordination of the TA implementation, including coordination of inputs by other consultants and the centers of excellence, and the preparation of knowledge products and TA reports. The consultant will

- (i) liaise with the SDCD mission leader, developing member country (DMC) representatives, and partner organizations;
- (ii) map existing information resources on climate change risks and weather-induced disasters by sector, based on the input of the sector consultants;
- (iii) coordinate the development of the criteria and an inventory of critical infrastructure and climate risk and vulnerability assessments;
- (iv) in addition to providing overall coordination for outputs 1 and 2, be responsible for the delivery of output 3 and identify policy, financial priorities, adaptation options, and climate resilience design standards for the target sectors;
- (v) formulate recommendations on governance, policy, regulatory, financial measures, insurance, and risk transfer mechanisms that can be deployed to

- avoid locking in critical infrastructure and their services to long-term climate vulnerability;
- (vi) examine approaches to climate risk management, including those developed by ADB and other financial institutions; potential engineering solutions based on high technology that can be developed to reduce climate risks; and potential non-engineering measures such as ecosystem-based adaptation that can be retrofitted to existing infrastructure and applied to the design of new infrastructure to increase resilience to climate change and disaster risk;
  - (vii) develop indicators that can be used to measure the effectiveness of climate-resilient designs and develop climate resilient infrastructure design metrics or standards for the target sectors, taking into account the different needs and national circumstances and the work done by other institutions on designing resilient infrastructure;<sup>1</sup>
  - (viii) be responsible for coordinating the development of case studies for three DMCs to demonstrate the benefits of investing in climate resilience; and
  - (ix) develop recommendations on national and regional opportunities for investment with significant climate change adaptation and/or disaster risk management (DRM) benefits, and assess associated benefits in accordance with national development plans (including sector plans, national adaptation programs of action, intended nationally determined contributions, and joint national action plans for disaster risk management and climate change adaptation).

5. **Climate change economist** (3 person-months, intermittent). The consultant will be responsible for the economic analyses and studies required to inform the identification of critical infrastructure and assess available engineering and non-engineering adaptation options to increase the resilience of the critical infrastructure. The consultant will

- (i) estimate the economic costs of the potential impacts to critical infrastructure resulting from the projected changes of relevant climate variables, including sea level, which are identified in outputs 1 and 2;
- (ii) assess the economic costs and benefits of possible adaptation measures as identified in output 3;
- (iii) provide recommendations based on the outcomes of the economic analysis;
- (iv) provide inputs for the development of knowledge products, including technical assessment reports and journal publications; and
- (v) contribute as a resource person to knowledge dialogues and consultations.

6. **Transport consultant** (2 person-months, intermittent). The consultant will be responsible for the assessment of the impacts of climate change on critical infrastructure in the transport sector; and the identification of measures, technology, policy, and knowledge solutions that can be incorporated into transport projects to increase the climate resilience of infrastructure investments. The consultant will

- (i) provide transport sector-specific expertise in mapping existing information resources on climate change risks and weather-induced disasters;
- (ii) identify sector risks associated with climate change;
- (iii) conduct an assessment of and summarize the available literature, databases, and other relevant sources to inform the vulnerability assessment of critical infrastructure in the transport sector;

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<sup>1</sup> This includes work on the climate adaptation standards being undertaken by the International Organization for Standardization and the standard for sustainable and resilient infrastructure developed by the Global Infrastructure Basel Foundation.

- (iv) in collaboration with the team leader and the centers of excellence, develop a system, model, or a set of criteria to classify transport infrastructure that is essential to sustain the core economic activity in a region or country;
- (v) provide sector-specific recommendations on national and regional opportunities for investment with significant climate change adaptation and DRM benefits;
- (vi) develop climate resilience standards for transport sector investments;
- (vii) provide inputs for the development of knowledge products, including technical assessment reports and journal publications; and
- (viii) contribute as a resource person to the TA knowledge dialogues, workshops, and consultations.

7. **Energy consultant** (2 person-months, intermittent). The consultant will be responsible for the assessment of the impacts of climate change on critical infrastructure in the energy sector; and the identification of measures, technology, policy, and knowledge solutions that can be incorporated into energy sector projects to increase the resilience of infrastructure investments. The consultant will

- (i) provide energy sector-specific expertise in mapping existing information resources on climate change risks and weather-induced disasters;
- (ii) identify risks in the energy sector associated with climate change;
- (iii) conduct an assessment of and summarize the available literature, databases, and other relevant sources to inform the vulnerability assessment of critical infrastructure in the energy sector;
- (iv) in collaboration with the team leader and the centers of excellence, develop a system, model, or a set of criteria to classify energy infrastructure that is essential to sustain the core economic activity in a region or country;
- (v) provide sector-specific recommendations on national and regional opportunities for investment with significant climate change adaptation and DRM benefits;
- (vi) develop climate resilience standards for transport sector investments;
- (vii) provide inputs to the development of knowledge products, including technical assessment reports and journal publications; and
- (viii) contribute as a resource person to the TA knowledge dialogues, workshops, and consultations.

8. **Water consultant** (2 person-months, intermittent). The consultant will be responsible for the assessment of the impacts of climate change on critical infrastructure in the water sector; and the identification of measures, technology, policy, and knowledge solutions that can be incorporated into water sector projects to increase the resilience of infrastructure investments. The consultant will

- (i) provide water sector-specific expertise in mapping existing information resources on climate change risks and weather-induced disasters;
- (ii) identify risks in the water sector, including risks to urban and rural water supplies, that are associated with climate change;
- (iii) conduct an assessment of and summarize the available literature, databases, and other important sources of information to determine the critical infrastructure in the water sector;
- (iv) develop and apply hydrologic and/or hydraulic models as required to support the assessment;
- (v) in collaboration with the team leader and the centers of excellence, develop a system, model, or a set of criteria to classify water sector infrastructure that is essential to sustain the core economic activity or basic social services in a region or country;

- (vi) provide sector-specific recommendations on national and regional opportunities for investment with significant climate change adaptation and DRM benefits;
- (vii) develop climate resilience design standards for water sector infrastructure;
- (viii) provide inputs to the development of reports and knowledge products, including technical assessment reports and journal publications; and
- (ix) contribute as a resource person to the TA's knowledge dialogues, workshops, and consultations.

9. **Geographic information systems consultant** (4 person-months, intermittent). Under the direction of the team leader and sector specialists, the consultant will be responsible for preparing geo-spatial coverage of critical infrastructure and its physical and human geographic context in the urban and rural transport, energy, and water sectors in the target countries. Specific information will include (i) geo-spatially referenced locations of critical transport, energy, and water infrastructure as determined by the sector specialists; (ii) digital elevation terrain models at horizontal and vertical resolution appropriate to the methodology used in risk assessment; (iii) major hydrologic features, particularly major river systems and surface water bodies (both natural and artificial) at a level of detail required to support hydrologic and hydraulic modeling; (iv) land use and land cover as required for the assessments; (v) climatic features of the target countries at reasonably high spatial resolution (both historical and projected climate); (vi) distribution of population at a degree of resolution consistent with the modeling of demand for water and energy; and (vii) maps, reports, and graphics prepared as required for reports, knowledge products, and web content.

### C. National Consultants

10. **TA coordinator** (12 person-months, intermittent). The TA coordinator will be based in ADB headquarters in Manila and will provide administrative support in the implementation of the TA activities. Specifically, the TA coordinator will (i) carry out necessary administrative tasks to ensure timely implementation of TA activities and coordination within ADB and externally; (ii) monitor the TA budget and prepare financial reports; (iii) assist the team leader in the preparation of a TA progress report, a completion report, and other reports that may be required; (iv) support the preparation and organization of workshops; (v) provide support to the TA consultants and act as a liaison between the consultants, SDCD, and operations departments; and (vi) provide support as required to ensure the smooth implementation of TA activities.

11. **National consultants** (1 consultant from each of the 3 target DMCs, 6 person-months each, intermittent). The national consultants will facilitate access to local data and contribute to the development of national case studies.

12. **Knowledge management expert** (6 person-months, intermittent). The knowledge management expert will assist the team leader in developing a communications plan for all publications that will be developed under the TA. The consultant's tasks will include (i) developing a time line for all studies and publications; (ii) reviewing drafts and ensuring the quality of the reports; (iii) developing a launch plan for the publications; (iv) assisting in the international peer review process of a knowledge product; and (v) developing information brochures, flyers, and other knowledge products that may be required by the project officer.