INTEGRATED APPROACH FOR COST-EFFECTIVE DISASTER RISK MANAGEMENT

Jinqiang Chen, Jianping Yan, and Weijun Zhang

NO. 71

September 2024

ADB EAST ASIA WORKING PAPER SERIES

ASIAN DEVELOPMENT BANK

ADB

ADB East Asia Working Paper Series

Integrated Approach for Cost-Effective Disaster Risk Management

Jinqiang Chen, Jianping Yan, and Weijun Zhang

No. 71 | September 2024

Jinqiang Chen, urban development specialist (climate change) and TA project manager

Jianping Yan, international regional cooperation specialist

Weijun Zhang, international urban disaster risk management specialist

ASIAN DEVELOPMENT BANK


Creative Commons Attribution 3.0 IGO license (CC BY 3.0 IGO)

6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines
Tel +63 2 8632 4444; Fax +63 2 8636 2444
www.adb.org

Publication Stock No. WPS240461-2
DOI: http://dx.doi.org/10.22617/WPS240461-2

Notes:
In this publication, "CNY" refers to the Chinese yuan.
ADB recognizes "China" as the People's Republic of China.

The *ADB East Asia Working Paper Series* is a forum for stimulating discussion and eliciting feedback on ongoing and recently completed research and policy studies undertaken by the East Asia Department of the Asian Development Bank (ADB) staff, consultants, or resource persons. The series deals with key economic and development problems, as well as conceptual, analytical, or methodological issues relating to project/program economic analysis, and statistical data and measurement. The series aims to enhance the knowledge on Asia's development and policy challenges; strengthen analytical rigor and quality of ADB's country partnership strategies, and its subregional and country operations; and improve the quality and availability of statistical data and development indicators for monitoring development effectiveness.

The *ADB East Asia Working Paper Series* is a quick-disseminating, informal publication whose titles could subsequently be revised for publication as articles in professional journals or chapters in books. The series is maintained by the East Asia Department.

CONTENTS

TABLES, FIGURES, AND BOXES

TABLES

FIGURES

BOXES

ABBREVIATIONS

ADB	–	Asian Development Bank
CEA	–	cost-effectiveness analysis
DRM	–	disaster risk management
DRR	–	disaster risk reduction
EASM	–	East Asian Summer Monsoon
ESG	–	environmental, social, and governance
IDRM	–	integrated disaster risk management
PRC	–	People's Republic of China
TA	–	technical assistance

ACKNOWLEDGMENTS

This working paper is partially based on the implementation of a technical assistance (TA) project, Integrated Framework for Cost-Effective Disaster Risk Management, supported by the Asian Development Bank (ADB).

Preparation of this working paper was led by Jinqiang Chen, urban development specialist (climate change) and TA project manager. Technical data and inputs for this paper were provided by TA consultants Jianping Yan, international regional cooperation specialist; and Weijun Zhang, international urban disaster risk management specialist.

The paper benefited from comments of Fengmin Kan, former chief of the Asia Pacific Regional Office, United Nations Office for Disaster Risk Reduction; Sifayet Ullah, disaster risk management specialist, ADB; and Jingmin Huang, director, Water and Urban Development Sector Office, ADB.

EXECUTIVE SUMMARY

The working paper provides a comprehensive framework developed under the Asian Development Bank's (ADB) technical assistance project, Integrated Framework for Cost-Effective Disaster Risk Management. This framework aims to provide a reference to decision-makers in their deliberation of various disaster risk management (DRM) measures in the process of disaster resilience investment.

This paper outlines the critical interconnections between disasters, climate change, and development, emphasizing the necessity for a proactive and integrated approach to DRM to mitigate the adverse impacts of natural hazards and support sustainable development. It highlights the ongoing shift in disaster management paradigms—from reactive responses to proactive, integrated risk management approaches that engage multiple sectors and stakeholders.

Key components of the paper include the following:

(i) An examination of the disaster risk profile of the People's Republic of China, detailing the significant exposure and vulnerability to natural hazards amplified by rapid urbanization and climate change. Uncertainties associated with climate change and socioeconomic development necessitate a robust decision-making process that considers both direct benefits and co-benefits of DRM measures to achieve low-regret DRM investment.

(ii) An integrated approach for DRM taken by decision-makers to reduce disaster risks and manage residual risks, contributing to the strengthening of resilience and reduction of disaster losses. Disaster risk reduction (DRR) strategies encompass a wide range of interventions, including hazard mitigation, exposure control, and vulnerability reduction. When DRR strategies are no longer cost-efficient, DRM seeks alternative solutions that focus on preparedness and response to manage residual risks. Failure to explore the full range of DRM measures can often lead to inefficient allocation of limited resources, overlooked synergies, and introduction of new threats to the development process.

(iii) Prioritization procedures to facilitate decision-makers' deliberation of DRM measures in contexts of constrained financial and human resources. The prioritization process involves evaluating various DRM measures based on their cost-effectiveness, considering immediate benefits in terms of avoided disaster losses, and broader development co-benefits in line with economic development and environmental, social, and governance (ESG) principles (the triple dividends of resilience). Evaluating both direct and indirect benefits facilitates a more inclusive decision-making process by engaging a diverse array of stakeholders with varying priorities and perspectives. This approach can also mitigate the challenges posed by the uncertainties associated with climate change and socioeconomic development, as the inclusion of development impacts provides a critical reference point for decision-making.

(iv) A case study of urban flood risk management in Wuzhou City, illustrating the application of cost-effective analysis (CEA) in prioritizing DRM interventions.

The purpose of this working paper is to improve awareness and mindset, facilitating a shift toward more strategic and informed DRM practices. The application of the outlined methodology in the real-world decision-making process may face various challenges, including data availability, willingness for innovation, and institutional silos, which can vary greatly depending on the level of sophistication. Addressing these challenges is a collective endeavor and is crucial for building resilient infrastructures and communities equipped to adapt to, and thrive in the face of, inevitable future challenges. ADB should apply the outlined methodology and principles in the whole cycle of its engagement with its developing member countries to cost-effectively invest in disaster resilience, running through its upstream, midstream, and downstream operations.

I. INTRODUCTION

Disasters, climate change, and development are highly interlinked. During the earlier stages of human development, development policies and practices did not generally consider the possible impact of disaster resilience, climate change, and the natural environment, focusing solely on the concrete results of development projects, large or small. This has led to accumulation of exposure and vulnerability of populations and socioeconomic assets to natural hazards and climate change; thus, a considerable number of disaster and climate risks are now challenging sustainable development worldwide.

Ongoing national and international efforts in disaster risk management have proven inadequate to stop the trend of increasing impacts of disasters on development. The frequency and magnitude of weather-related disasters continue to be on the rise and rapid urbanization increases exposure of people and assets to hazards, outpacing the reduction in vulnerability. These interlinked negative relationships are common challenges for all countries. Achieving sustainable development now requires reversing this trend through coherent policies, legislation, and proactive measures.

Since 1990, all Asian countries have been working together under the coordination of the United Nations (UN) to address these common development challenges through implementation of three international frameworks on disaster management and disaster risk reduction that were approved in 1994, 2005, and 2015.[1] Much has been achieved and most countries have set up national institutions, frameworks, policies, legislation, and even emergency relief funds to reduce the negative impact of disasters triggered by natural hazards. More importantly, all countries have progressively accepted the concept that disasters are not natural, but an undesired by-product of previous development processes. Most countries have moved progressively from solely disaster management to disaster risk management (DRM), thus from reactive to proactive; and from sole responsibility for disaster management by one agency to a shared responsibility among all concerned development stakeholders.

The Political Declaration on the Midterm Review of the Sendai Framework for Disaster Risk Reduction 2015–2030 (the Sendai Framework), adopted by the UN General Assembly in May 2023, conveys a deep concern: "the pace of implementation of the Sendai Framework is not sufficient nor equal."[2] It highlights that insufficient access to disaster data, risk knowledge, technology and financing, as well as insufficient prioritization and action on disaster risk reduction, including through climate action, continues to hinder progress in implementing the Sendai Framework.

The Asian Development Bank (ADB) has demonstrated strong and sustainable commitment to provide technical and financial assistance to Asian countries so they can achieve sustainable development through DRM, tackling climate change, building resilience, and enhancing environmental sustainability in its members.[3] Over the years, ADB has provided assistance in pursuing an integrated approach to DRM in developing member countries, reducing the growing exposure and vulnerability to natural hazards and addressing disaster and climate risks in Asia and the Pacific.[4]

---

1 Yokohama Strategy and Plan of Action for a Safer World,1994; Hyogo Framework for Action, 2005; Sendai Framework for Disaster Risk Reduction, 2015.

2 UN General Assembly. 2023. *Political Declaration of the High-Level Meeting on the Midterm Review of the Sendai Framework for Disaster Risk Reduction 2015–2030*. Resolution adopted by the General Assembly on 18 May 2023. para. 5.

3 ADB. 2018. Strategy 2030: Operational Plan for Priority 3—Tackling Climate Change, Building Climate and Disaster Resilience, and Enhancing Environmental Sustainability, 2019–2024. *Strategy 2030: Achieving a Prosperous, Inclusive, Resilient, and Sustainable Asia and the Pacific.*

4 See for example, ADB. 2018. Tajikistan: National Disaster Risk Management Project; and ADB. 2016. Pakistan: National Disaster Risk Management Fund.

As challenges imposed by disasters cut across all development sectors and processes, cost-effective solutions can only be found by first integrating DRM in development policies, decisions, and implementation for the long term. The ADB-supported technical assistance (TA) project, Integrated Framework for Cost-Effective Disaster Risk Management, is the first-ever cross-ministry and cross-agency TA project in the People's Republic of China (PRC).[5] The TA project, involving three central government ministries and two local government agencies, aims to address the much-needed capacity building in DRM. The TA was designed to cover a broader spectrum of DRM, focusing on integrated solutions and improving institutional arrangements and governance across five involved ministries and agencies. The TA built a framework that assesses (i) the cost-effectiveness of DRM measures, taking into account demographic and economic heterogeneity, including gender and income; and (ii) the local impact of climate change. Doing so enabled decision-makers to factor in co-benefits of DRM measures; economic development benefits; as well as environmental, social, and governance (ESG) factors in their consideration of proposed DRM measures. The TA additionally supported the PRC's efforts to boost regional collaboration on disaster resilience investments.

This paper shows how DRM synergistically underpins sustainable development. A case study in urban flood risk management in Wuzhou, PRC, is presented, which illustrates the application of cost-effectiveness analysis (CEA) in prioritizing DRM interventions. The data used in this paper are highly simplified and partially reflect the initial lessons and observations of the authors.

The paper aims to contribute to ADB's promotion of sustainable development on DRM, and to serve as a reference for government agencies across all levels in their development planning and deliberation of DRM measures. The objectives of the paper are as follows:

(i) underscore the significance of an integrated approach for cost-effective DRM to achieve resilience to disaster and climate risks;
(ii) highlight prioritization procedures based on cost-effective principles that factor in direct benefits and co-benefits for different stakeholders concerned; and
(iii) share insights on the way forward to further enhance implementation of the integrated approach for cost-effective DRM in future development investments of ADB.

Additionally, the paper hopes to be a valuable resource for international organizations and development agencies and help them in providing customized and effective DRM solutions to their client countries.

II. DISASTER RISK PROFILE OF THE PEOPLE'S REPUBLIC OF CHINA

The PRC is exposed to a wide range of disaster risks because of its vast geographical diversity, population density, and rapid urbanization. The country is highly vulnerable to natural hazards such as earthquakes, floods, droughts, cold rain, hot spells, typhoons and tropical cyclones, and landslides. According to the Ministry of Emergency Management, in 2023, natural hazards affected 95,444,000 person-times and resulted in direct economic losses of CNY345 billion. Water-related hazards, including floods and droughts, accounted for 77.3% of the person-times affected and 76.8% of the economic losses.[6]

[5] ADB. China, People's Republic of: Integrated Framework for Cost-Effective Disaster Risk Management (TA 6748-PRC).
[6] Ministry of Emergency Management of the People's Republic of China.

The East Asian Monsoon, primarily the East Asian Summer Monsoon (EASM), regulates the precipitation in the PRC. EASM is a subsystem of the largest monsoon system on Earth, the Asian Monsoon, which plays a crucial role in the entire Eastern Hemisphere's tropics, subtropics, and midlatitudes that affects 60% of the world's population.[7] EASM is susceptible to climate change, which exacerbates the frequency and intensity of disasters, increasing vulnerability across all disaster types and affecting the resilience of communities and their ecosystems. Recent impacts have been seen in the accelerated melting of Tibetan glaciers and the increase in extreme weather events.

Although EASM precipitation and the frequency and intensity of extremes are projected to increase in response to greenhouse gas warming in all time horizons and scenarios, a high level of uncertainty exists, as manifested in the wide spread of simulated precipitation across climate models.[8] A key factor contributing to this intermodal spread is the climatology of EASM. Even when using current climate conditions, state-of-the-art climate models fail to reproduce unanimous spatial patterns and rainfall amounts for the EASM, due in part to the spread in the simulated globally averaged precipitation, and primarily due to the disparate simulations of large-scale circulation.[9] Such a high level of uncertainty arising from the imperfection of forecasting poses a significant challenge for decision-making, since failing to manage those uncertainties will have serious consequences for climate adaptation and DRM. It is imperative for decision-makers to recognize those uncertainties and adopt robust technical solutions of which performance will not be materially compromised, or to use an economic term that will generate "low regret" across various plausible scenarios.[10]

The PRC's urban population has also surged dramatically, transforming the country from a largely rural society to one dominated by urban centers. In 1980, only about 20% of its population lived in urban areas.[11] By 2020, this urbanization rate had skyrocketed to about 60%, with more than 850 million people residing in cities.[12] Such rapid urbanization also presents significant challenges, often leading to land-use changes, such as the conversion of natural floodplains into urban infrastructure, which amplifies flood risks by diminishing natural water absorption capacities and altering runoff patterns. Additionally, migration trends contribute to a demographic imbalance in rural areas, which are mostly populated by older people and youths. This weakens local disaster response capacities and also undermines efforts to eradicate poverty sustainably, as disasters can perpetuate the cycle of poverty and impair households' long-term development prospects.

The Government of the PRC has introduced legislation and policies to address the combined impact of disasters, climate change, environmental degradation, and rapid urbanization. There has been a clear shift from reactive response to proactive action, that is, from focusing on disaster management alone to broader DRM. In recent years, the government has also demonstrated a strong willingness to obtain ADB assistance in integrated DRM for resilience to disasters, especially those related to climate change.

---

7 B. Wang. 2006. *The Asian Monsoon.* Springer Praxis.

8 Z. Chen et al. 2020. Global Land Monsoon Precipitation Changes in CMIP6 Projections. *Geophysical Research Letters*. 47 (14). e2019GL086902; D. Li, T. Zhou, and W. Zhang. 2019. Extreme Precipitation over East Asia under 1.5°C and 2°C Global Warming Targets: A Comparison of Stabilized and Overshoot Projections. *Environmental Research Communications*. 1 (8).

9 J. Chen and S. Bordoni. 2014. Inter-Model Spread of East Asian Summer Monsoon Simulations in CMIP5. *Geophysical Research Letters*. 41. pp. 1314–1321.

10 "Regret" refers to the difference between the utility of a decision and the utility that would have been obtained from the optimal decision in that same scenario. "Low regret" decisions have high utility no matter what the future brings.

11 World Bank. Urban Population (% of total population)—China (accessed 5 September 2024).

12 National Bureau of Statistics of China. 2021. *China Statistical Yearbook 2021*.

III. INTEGRATED APPROACH FOR COST-EFFECTIVE DISASTER RISK MANAGEMENT

As opposed to traditional disaster response, integrated disaster risk management (IDRM) comprises disaster risk prevention, reduction, and residual risk management, contributing to the strengthening of resilience and reduction of disaster losses. It is an advanced approach, developed based on an improved understanding of the interrelationship of disaster, climate change, and development; and based on the acceptance that the major causes of disasters are deeply rooted in long-practiced development policies and practices where considerations of natural hazards, exposure, and vulnerability were largely overlooked. It also acknowledges that disaster risks cannot be fully eliminated, and residual risks need be properly managed through effective disaster preparedness and response. The integrated approach for DRM addresses the complex nature of disaster risks throughout the development process, including development policy, planning, decision-making, investment, and operations. Only in this way can disaster risks (hazards, exposure, and vulnerability) be prevented, reduced, and managed.

The "integrated approach for cost-effective DRM" is an approach that adds prioritization based on CEA of the ongoing application of IDRM. On one hand, the integrated approach for cost-effective DRM makes the best use of limited resources currently available for DRM, and on the other, it is a smart investment for resilient and sustainable development. It can also bring extensive direct and indirect benefits across the three pillars of sustainable development—the social, economic, and environmental domains.

A. Integrated Approach for Disaster Risk Management

Disaster risks represent a complicated challenge across the three pillars for sustainable development; thus, managing disaster risks becomes a shared responsibility across development sectors. IDRM has been used as a tool to facilitate a paradigm shift toward a holistic, inclusive, and forward-thinking approach in resilience building, through deployment of various DRM measures, including hazard prevention and mitigation, exposure control, vulnerability reduction, disaster preparedness, disaster response, and disaster risk transfer. During the process, it is important to secure the technical capacity and interest of key stakeholders, as well as local knowledge and concerns from communities, including the most vulnerable and socially disadvantaged groups. This will also provide an opportunity to apply gender equality and social inclusion analysis to make risk-informed development projects more gender-sensitive and sensitive to the interests of vulnerable groups.

ADB's 2021 *Revised Disaster and Emergency Assistance Policy* highlights that IDRM begins with disaster risk reduction (DRR), which aims to prevent or mitigate the impacts of disasters before they occur and should be fully integrated into the development process.[13] Effective DRR strategies encompass a wide range of interventions, including hazard mitigation, exposure control, and vulnerability reduction. These strategies are implemented through both structural measures (such as flood defenses and earthquake-resistant buildings) and nonstructural measures (such as comprehensive land-use planning and stringent building codes). When DRR strategies are no longer cost-efficient, DRM seeks alternative solutions. These involve disaster preparedness and response as key components of managing residual risk, thus ensuring a minimized impact from those risks that cannot be entirely avoided.

Key guiding principles of IDRM include the following:

[13] ADB. 2021. *Revised Disaster and Emergency Assistance Policy.*

(i) ***Apply the highly recognized risk management steps of the International Organization for Standardization.*** This involves establishing the context, risk identification, risk analysis, risk evaluation, and risk treatment prior to investment selection, supported by risk communication and consultation as well as risk monitoring and review during implementation.

(ii) ***Make IDRM gender-sensitive and socially inclusive.*** This is a win-win option as voices are heard, participation is secured, and people learn and contribute to DRM, eventually enjoying disaster resilience with others.

(iii) ***Secure adequate governance and capacity for IDRM***. Development managers and practitioners should integrate DRM in the entire cycle of development projects, as governance and capacity are key enablers to achieve resilience.

(iv) ***Promote multistakeholder cooperation and collaboration.*** Disaster and climate risks are far beyond the capacity and technical know-how of any one group of stakeholders to reduce and manage. Multistakeholder collaboration provides effective solutions to the challenges imposed by disaster and climate risks.

(v) ***Document best practices and lessons learned.*** In situations where IDRM has not yet been mainstreamed in development processes, documentation will provide an invaluable reference. This will cover both good practices and lessons learned for further integration of DRM into the whole cycle of future development projects.

An integrated approach for DRM in development planning and climate change adaptation initiatives signifies a commitment to not only reducing impacts of disasters, but also preventing them by managing disaster risks, making these initiatives a cornerstone of sustainable development. As challenges persist and new disaster risks emerge, the integrated approach to DRM prepares societies to manage existing risks and equips them to adapt to future uncertainties with greater agility and confidence.

B. Prioritizing Disaster Risk Management Measures Based on Cost-Effective Analysis

1. Prioritizing Disaster Risk Management Intervention

Once decision-makers are exposed to various disaster risk management measures, the immediate question becomes which measures should be deployed. This underscores the necessity of prioritization. Prioritizing DRM interventions is essential primarily because both financial and human resources are inherently limited. It is crucial to allocate these resources effectively to maximize the impact of DRM efforts that are aimed at saving lives, reducing economic losses, and enhancing resilience to disasters.

The prioritization process involves evaluating various DRM actions based on their potential impacts and outcomes, selecting those that offer the greatest immediate benefits in terms of avoided disaster losses, while also contributing to broader development in line with economic benefits and ESG principles (often referred to as triple dividends of resilience; see following section). This ensures that interventions are effective and also yield additional development benefits. This approach is particularly important to achieve low regret in the decision-making process in the context of deep uncertainties due to climate change and socioeconomic development.

2. Indicators of Prioritization

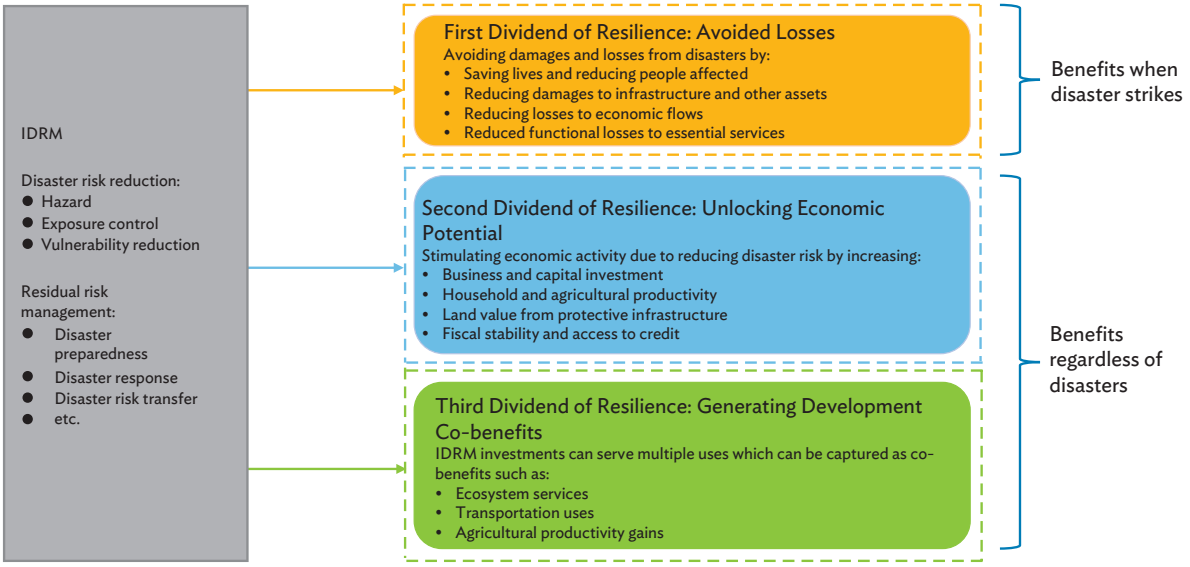
The paper identifies various indicators to capture the multiple benefits of building resilience to disaster and climate risks, on top of the mature framework often used in the development community, that is, the

triple dividends of resilience.[14] This concept emphasizes that investments in resilience save lives, reduce losses in disaster events, stimulate economic growth, and deliver additional social and environmental benefits, even in the absence of a disaster. This concept aligns well with the principle that IDRM is an integral part of any socioeconomic development process.

The triple dividends of resilience aim to encourage stakeholders to recognize the comprehensive range of benefits that resilience investments can yield. This perspective is particularly valuable in the face of deep uncertainties associated with disasters, including climate change and socioeconomic shifts, as the framework seamlessly integrates with broader development strategies. The framework highlights the co-benefits of DRM interventions, which are advantageous regardless of whether disasters occur. By focusing on DRM interventions that yield both economic and ESG benefits, stakeholders can reduce the regrets associated with decision-making based solely on the direct benefits of DRM interventions, which are often challenging to estimate due to the associated uncertainties.

The triple dividends of resilience framework in Figure 1 show the extensive benefits that arise from investing in resilience, where the first dividend is the direct benefit and the rest of the dividends are the co-benefits.

Figure 1: The Triple Dividends of Resilience Framework



IDRM = integrated disaster risk management.

Sources: Adapted from T. Tanner, et al. 2015. *The Triple Dividend of Resilience: Realising Development Goals Through the Multiple Benefits of Disaster Risk Management*. Global Facility for Disaster Reduction and Recovery at the World Bank and Overseas Development Institute; S. Surminski and T. Tanner, eds. 2016. *Realising the "Triple Dividend of Resilience": A New Business Case for Disaster Risk Management*. Springer; H. Heubaum et al. 2022. The Triple Dividend of Building Climate Resilience: Taking Stock, Moving Forward. *Working Paper.* World Resources Institute.

[14] See T. Tanner et al. 2015. *The Triple Dividend of Resilience: Realising Development Goals Through the Multiple Benefits of Disaster Risk Management*. Global Facility for Disaster Reduction and Recovery at the World Bank and Overseas Development Institute; S. Surminski and T. Tanner, eds. 2016. *Realising the "Triple Dividend of Resilience": A New Business Case for Disaster Risk Management*. Springer; H. Heubaum et al. 2022. The Triple Dividend of Building Climate Resilience: Taking Stock, Moving Forward. *Working Paper.* World Resources Institute.

Below is a list of the benefit indicators as categorized into the three groups. The indicators presented here are not exhaustive, but are intended to inform and shed light while offering flexibility, allowing policymakers to adopt and tailor indicators to their specific needs.

(i) **First Dividend of Resilience: Avoided Damage and Losses.**[15] This category comprises immediate benefits from resilience investments, primarily in terms of disaster risk mitigation, such as the following:
   (a) Save lives by reducing the number of human casualties.
   (b) Reduce the number of people affected (i.e., increasing the number of people who are safe during a disaster by reducing the number of injuries, displacement, or loss of livelihoods.)
   (c) Reduce damage to assets by avoiding monetary loss with reduced physical damage to infrastructure and property.
   (d) Reduce loss to economic flows by minimizing interruptions to economic activities due to disasters. This is often measured as the increase in gross domestic product or other economic indicators attributable to resilience measures.
   (e) Reduce functional losses to essential services, such as health care, emergency services, transportation, power and energy supply, communication, water supply and sanitation, and social protection.

(ii) **Second Dividend of Resilience: Unlocking Economic Potential**. This refers to the economic co-benefits that resilience measures can bring, regardless of whether a disaster event occurs. These benefits include the following:
   (a) Increase in business and capital investment, measured in terms of monetary value of increased investments arising from improved resilience.
   (b) Increase in household and agricultural productivity, as seen in the increase in production or efficiency in household or agricultural activities due to improved resilience.
   (c) Increase in land value from protective infrastructure, as seen in the rise in monetary value of land resulting from the construction of protective infrastructure such as sea walls or levees.
   (d) Increase in fiscal stability and access to credit resulting from improved resilience, which can lead to better fiscal stability and improved access to credit for governments, businesses, and households.
   (e) Increase in employment opportunities or the creation of dedicated skilled-job opportunities stemming from resilience investment activities.

(iii) **Third Dividend of Resilience: Generating Development Co-benefits.** The ESG co-benefits are brought about by resilience measures regardless of whether a disaster event occurs. Box 1 contains examples of these co-benefits.

[15] Deliberations on DRM measures should not be driven solely by the goal of reducing asset losses, as this approach overlooks the disproportionate distribution of assets across the population. Low-income people, possessing limited assets, risk being neglected in DRM strategies focused primarily on minimizing asset losses. Instead, decision-making on DRM investments should prioritize reducing welfare losses, taking into account the impact of disasters on public and household consumption.

Box 1: Environmental, Social, and Governance Benefits of Disaster Risk Management Measures

Environmental Benefits	(i)	Improved environmental quality: As part of broader resilience efforts, strategic changes in land use and agricultural practices, adoption of cleaner energy sources, and upgrades of transportation systems all contribute to environmental restoration.
	(ii)	Improved water conservation: Improved land use and agricultural practices integrated into disaster risk reduction and resilience strategies contribute to considerable water savings.
	(iii)	Improved biodiversity conservation: Measures like reforestation, afforestation, and ecosystem-based adaptations enhance habitat and biodiversity, providing long-term environmental benefits.
	(iv)	Reduced carbon emissions: Resilience measures can lead to a measurable decrease in greenhouse gas emissions.
Social Benefits	(i)	Enhanced community cohesion and social capital: Community-based projects that promote collaboration among residents strengthen social ties and foster community spirit. These networks are invaluable during the recovery phases following disasters, facilitating mutual aid and information sharing.
	(ii)	Improved public health: Resilience investments can provide access to health care, reduce the likelihood of disease outbreaks, and resolve mental health issues, leading to better health outcomes.
	(iii)	Enhanced development sustainability: Resilience measures that are inclusive and consider the diverse needs and capacities of all community members help to address and alleviate underlying vulnerabilities, such as poverty, discrimination, and incapacity, building resilience at individual and community levels.
	(iv)	Improved education continuity: Investments in resilient infrastructure help ensure that educational facilities can withstand disasters and minimize disruptions to schooling, which is crucial for long-term social and economic development.
	(v)	Enhanced gender equality: An integrated approach for disaster risk management promotes more equal participation of all genders in decision-making processes.
Governance Benefits	(i)	Strengthened institutional capacity: Resilience investments enhance institutional operations, including better data management, planning, and regulatory enforcement.
	(ii)	Enhanced stakeholder engagement: By involving a wide range of stakeholders in resilience initiatives, decision-making processes are improved, making them more inclusive and effective.
	(iii)	Enhanced transparency: Increased information sharing in resilience measures fosters greater transparency and accountability across the board.

Source: Asian Development Bank.

The benefit indicators outlined above and their connections to global agendas are detailed in Appendix 1. Appendix 2 summarizes the most relevant benefit indicators for typical IDRM interventions. Decision-makers will have the flexibility to adopt benefit indicators in their deliberation of IDRM interventions. The following section outlines the methodology that decision-makers could use to translate these selected indicators into informed decisions.

3. Process of Prioritizing Disaster Risk Management Interventions

Prioritizing DRM interventions generally involves a structured multistep process that enables decision-makers to systematically evaluate various options and prioritize those that are more cost-effective. The process outlined below offers a systematic procedure for decision-makers to follow, while also allowing the flexibility to tailor indicators to their specific needs. This evaluation is based on their objectives, options to reduce risk, the resources required, and their alignment with broader development goals. Therefore, CEA in DRM interventions involves four steps:

Step 1: Defining the Objectives

(i) *Articulate disaster reduction goals (first dividend).* Clearly state the immediate objectives, such as reducing asset losses or casualties from disasters like floods.
(ii) *Boundary of analysis.* Determine the spatial and temporal scales, sectors, and stakeholders to be considered.

Step 2: Option Analysis of Integrated Disaster Risk Management Interventions

(i) *Develop intervention options.* Based on the initial disaster reduction goals, compile a list of potential DRM interventions through expert judgment, stakeholder consultations, and reviews of past practices.

Step 3: Cost-Effectiveness Analysis

(i) *Select benefit indicators and metrics for three dividends.* Choose appropriate indicators and metrics that will be consistent across all comparisons to ensure fairness and accuracy, although they may vary according to different decision-making contexts.
(ii) *Estimate benefits.* Evaluate the benefits of each intervention according to the dividends of resilience.
(iii) *Normalize and aggregate results.* Score each selected benefit indicator and combine these scores into an overall index using a weighting system. This step requires careful interpretation of the results and consideration of uncertainties in scoring and weighting. Also, ensure a balanced consideration of the distribution of benefits across different social groups and geographic areas.
(iv) *Quantify costs.* Document the costs associated with each intervention, including initial investments, operation, maintenance, and any other relevant expenses.

Step 4: Cost-Effectiveness-Based Decision-Making

(i) *Rank interventions.* Order the interventions based on composite indexes under each dividend within the constraints of the available budget.
(ii) *Identify the most cost-effective intervention.* Determine which intervention offers the best value for money across the three dividends. Prioritization should first focus on options that score highly across all three dividends. Next in line are options that achieve high rankings in the first dividend but may have lower scores in the second or third dividends. Following these, consider options that score low in the first dividend but are highly ranked in the second and/or third dividends, or options that score high in the first dividend but low in the second and/or third dividends. Lastly, options that score low across all three dividends should be given the lowest priority.
(iii) *Assess feasibility and implementability.* Evaluate the practicality and ease of implementing the chosen interventions. This evaluation occurs after the CEA to ensure that interventions are not dismissed solely due to implementation challenges. Based on the merits identified, policymakers should consider the feasibility of implementation, and if necessary, undertake policy and institutional reforms to facilitate these interventions.

During the prioritization process, it is critical to align DRM interventions with strategic development goals. As different countries and regions have their unique development priorities, DRM measures must align with these to ensure broad-based support and coherence in their implementation. Moreover, social acceptance plays a vital role: prioritizing interventions that are well received by their communities, thereby fostering community ownership and ensuring their success. Last, feasibility is critical. The local context—including technical, institutional, and financial capacities—must be assessed to choose interventions that

are realistic and implementable in specific settings. This comprehensive approach to prioritizing DRM interventions ensures that limited resources have the most significant and sustainable impact possible.

Cost-effective analysis involves comparing the unit costs of achieving specific outcomes that cannot be quantified in economic terms. This type of analysis is crucial to an integrated approach for DRM because it facilitates the involvement of multiple stakeholders and allows for the incorporation of their diverse priorities and perspectives, which are often challenging to monetize. Cost-effective analysis helps decision-makers prioritize interventions that offer the highest utility returns under budget constraints. Moreover, this analysis encourages a broader consideration of both the long-term and indirect costs and benefits, enhancing the overall understanding of the broad value of investments in resilience building, in line with the triple dividends of resilience.

IV. APPLYING THE COST-EFFECTIVE INTEGRATED APPROACH IN URBAN FLOOD RISK MANAGEMENT—PILOT CASE STUDY IN WUZHOU CITY

This case study illustrates the application of cost-effectiveness analysis (CEA) for managing urban flood risks, focusing on Changzhou district, a 134-square-kilometer area within Wuzhou City, southeast of the Guangxi Zhuang Autonomous Region in the PRC. Data used in the case study, including social, economic, and various planning or research inputs, were collected through public channels and directly from relevant local departments in Wuzhou. Thirteen DRM interventions (projects and measures) were identified and prioritized following the four-step process as described in section 2:

(i) Step 1: Define the objectives
(ii) Step 2: Option analysis of integrated DRM interventions
(iii) Step 3: Cost-effectiveness analysis
(iv) Step 4: Cost-effectiveness-based decision-making

A. Wuzhou City and the Study Area

Wuzhou City is characterized by its elevated terrain on the outskirts, which gradually descends toward the central area. The urban landscape is intersected by several rivers, including the Xun, Xijiang, and Gui rivers. Notably, the Xun and Gui rivers converge within the city to form the Xijiang River, which collects water from various upstream catchments. Given its abundant rainfall and specific geographical features, Wuzhou frequently experiences floods that are notable for their high maximum water levels, substantial discharge volumes, and prolonged durations, posing significant challenges to urban flood prevention.

The city has seen rapid economic development as a result of various earlier flood protection works, which has spurred significant urban development. According to data from the Wuzhou Statistics Bureau, the urban population increased from 26.4% in 2010 to 30.5% in 2020. In the specific study area of Changzhou district, the urban population was approximately 303,000 as of 2023.

Wuzhou's flood prevention efforts have earned national and regional recognition. Designated as one of the PRC's 25 key flood prevention cities in 1987, the city has adopted comprehensive policies and planning documents to steer its flood mitigation and risk reduction strategies. These initiatives have contributed to a decreasing trend in losses from flood disasters in recent years. Despite significant

improvements in flood protection over the past few decades, Wuzhou continues to face challenges due to rapid economic growth, heightened public expectations for safety, and financial constraints.

B. Proposed Integrated Solutions for Flood Risk Management

The authors conducted a comprehensive flood risk assessment. A terrain elevation map with a 30-meter resolution and 2-hour rainfall events with return periods of 5, 10, 20, 50, and 100 years were utilized to produce flood inundation maps. Inundation depth was used as a vulnerability proxy and spatially gridded gross domestic product as a proxy for economic activities to estimate potential losses caused by pluvial floods at different return intervals.

Based on the flood risk assessment and in alignment with the government's existing flood control plans, 13 measures have been identified for the CEA (Table 1). The authors estimated the cost of each measure based on government plans (Figure 2).[16] The local government has approximately CNY780 million budgeted for mitigating flood risks.

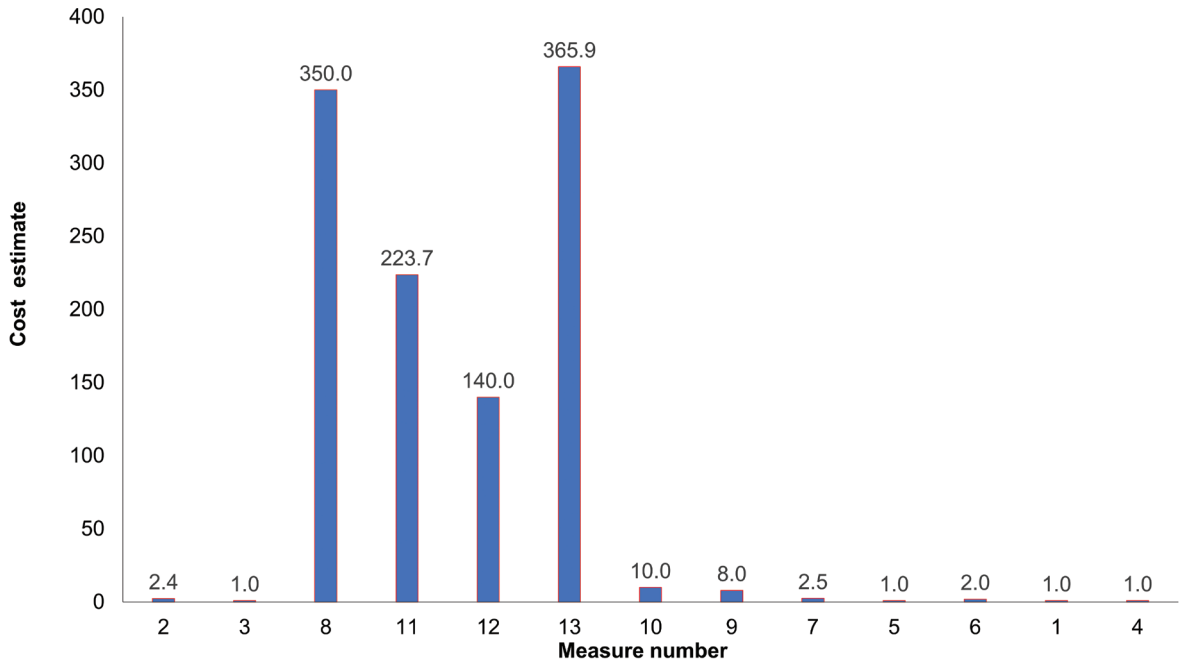
Table 1: Identified Disaster Risk Management Measures in Wuzhou

Measure No.	Name of Measure	Intervention Type
1	Wuzhou Flood Hazard Assessment and Risk Mapping Project	Resilience strengthening
2	Wuzhou Urban Resilience Action Plan	Resilience strengthening
3	Xijiang River Flood Control and Dike Upgrading Project	Hazard mitigation
4	River, Lake, and Reservoir Connection Project	Hazard mitigation
5	Wuzhou Urban Drainage and Waterlogging Comprehensive Treatment Project	Hazard mitigation
6	Source Sponge Construction Project	Hazard mitigation
7	Information Management and Control Platform for Urban Drainage and Flood Prevention	Resilience strengthening
8	Urban Hydraulic Modelling Project	Exposure control
9	Enhancement of public participation	Resilience strengthening
10	Participation of social groups in flood prevention and disaster reduction	Resilience strengthening
11	Establishment of financing mechanisms	Resilience strengthening
12	Catastrophe insurance	Resilience strengthening
13	Tax regulation, government subsidies, loan preferential policies	Resilience strengthening

Source: Authors' analysis based on consultations with local government departments.

[16] Cost estimates for Measures 3, 4, 5, and 6 are based on the Wuzhou 14th Five-Year Water Security Plan (2021–2025), Wuzhou Urban Water Resources Plan (2021–2035), Wuzhou Urban Drainage Master Plan (2017), and Wuzhou Sponge City Plan (2018). The costs for other measures were determined by the authors, referencing the Wuzhou 14th Five-Year Water Security Plan (2021–2025) and the Wuzhou Urban Flood Protection Emergency Response Plan (2022).

Figure 2: Estimated Costs of Flood Control and Risk Management Measures in Wuzhou
(CNY million)



Sources: Cost estimates for Measures 3, 4, 5, and 6 are based on the Wuzhou 14th Five-Year Water Security Plan (2021–2025), Wuzhou Urban Water Resources Plan (2021–2035), Wuzhou Urban Drainage Master Plan (2017), and Wuzhou Sponge City Plan (2018). The costs for other measures were determined by the authors, referencing the Wuzhou 14th Five-Year Water Security Plan (2021–2025) and the Wuzhou Urban Flood Protection Emergency Response Plan (2022).

C. Prioritizing Disaster Risk Management Interventions Through Cost-Effectiveness Analysis

The CEA-based prioritization of the 13 identified DRM measures for Wuzhou (as shown in Table 1) is summarized in Box 2.

Box 2: Prioritization of Disaster Risk Management Measures in Wuzhou Based on Cost-Effectiveness Analysis

Step 1: Define the Objectives

(i) Articulate disaster reduction goals (first dividend), that is, to achieve the expected flood protection standards while reducing potential disaster losses due to flooding.
(ii) Establish boundary of analysis: Changzhou District, Wuzhou City.

Step 2: Option Analysis of Integrated Disaster Risk Management Interventions

(i) Develop intervention options: These are the 13 disaster risk management measures.

continued on next page

Box 2 *continued*

Step 3: Cost-Effectiveness Analysis

(i) For the first dividend, avoiding damage and losses, the selected benefit indicators and metrics were the following:
  (a) Reduced people affected
  (b) Reduced damage to assets (points of interest)
  (c) Reduced loss to economic flows (losses)

(ii) For the second dividend, unlocking economic potential, the selected benefit indicators and metrics were the following:
  (a) Increased business and capital investment
  (b) Increased household and agricultural productivity
  (c) Increased land value from protective infrastructure
  (d) Increased fiscal stability and access to credit
  (e) Created jobs

(iii) For the third dividend, generating development co-benefits, the selected benefit indicators and metrics were the following:
  (a) Increased gender equality
  (b) Strengthened institutional capacity
  (c) Enhanced transparency
  (d) Enhanced stakeholder engagement

(iv) Evaluate benefits: For the first dividend, benefits of the measures were estimated from the flood risk assessment. Equal weights were assigned to each metric. For the second and third dividends, the scores were based on expert views and are only for illustrative purposes. Weights were assigned based on the perceived importance.

(v) Normalize and aggregate results: Associated values were normalized across all the interventions for each of the benefit indicators.

(vi) Quantify costs: Costs were estimated considering upfront capital and operation and maintenance costs.

Step 4: Cost-Effectiveness-Analysis-Based Decision-Making

(i) Rank interventions: Interventions ranked with high dividend within the budget limit were prioritized.

(ii) Identify the most cost-effective intervention: The 13 interventions were labeled with their overall priority levels.

(iii) Assess feasibility and implementability: The majority of the measures analyzed in this case study were sourced from the government's flood risk management report, indicating a high level of readiness. Interventions that are prioritized but not included in the government's project pipeline need further feasibility studies and assessment of institutional capacity. Implementing these highly prioritized interventions may require policy and institutional reforms to become viable. However, if implementing these measures incurs significant costs due to the absence of a mature market or supporting policies and regulations, decision-makers should consider discontinuing such interventions and reevaluating the analysis.

Source: Asian Development Bank.

In Step 3, the normalized values are aggregated into a final dividend index based on the assigned weight (Tables 2 to 4). Based on the normalized and aggregated results, in Step 4, interventions are ranked under each dividend (Figure 3). Table 5 shows the summary of prioritized interventions under each

dividend. In accordance with the prioritization criteria in Table 6, the 13 interventions are labeled with their overall priority levels (Table 7).

The authors would like to emphasize that the purpose of this case study is to demonstrate the procedure for conducting a CEA to prioritize DRM measures in a local context. The value assigned to the benefit indicators for each DRM intervention is illustrative and should not be interpreted as definitive. Additionally, the weighting system used is simplified and can be adjusted according to the preferences of decision-makers. The ultimate ranking of DRM interventions is neither suggestive nor indicative of their importance in the local context or beyond.

Table 2: Normalized and Aggregated Results for First Dividend

No.	Measures	Reduced People Affected ('000)	Normalized Value	Weight	Reduction in Damage to Assets (POI)[a]	Normalized Value	Weight	Reduction in Loss to Economic Flows (Losses)[b]	Normalized Value	Weight	Aggregated Value	Normalized Aggregated Value
1	Wuzhou Flood Hazard Assessment and Risk Mapping Project	15	0.08	1	120	0.05	1	23,406	0.17	1	0.10	35
2	Wuzhou Urban Resilience Action Plan	3	0.01	1	22	0.01	1	4,256	0.03	1	0.02	0
3	Xijiang River Flood Control and Dike Upgrading Project	75	0.39	1	589	0.27	1	15,007	0.11	1	0.26	100
4	River, Lake, and Reservoir Connection Project	20	0.11	1	380	0.17	1	17,266	0.12	1	0.13	49
5	Wuzhou Urban Drainage and Waterlogging Comprehensive Treatment Project	16	0.08	1	348	0.16	1	8,400	0.06	1	0.10	34
6	Source Sponge Construction Project	19	0.10	1	433	0.20	1	10,049	0.07	1	0.12	44
7	Information Management and Control Platform for Urban Drainage and Flood Prevention	8	0.04	1	66	0.03	1	12,767	0.09	1	0.05	15
8	Urban Hydraulic Modelling Project	8	0.04	1	66	0.03	1	12,767	0.09	1	0.05	15
9	Enhancement of public participation	4	0.02	1	29	0.01	1	5,674	0.04	1	0.02	3
10	Participation of social groups in flood prevention and disaster reduction	4	0.02	1	29	0.01	1	5,674	0.04	1	0.02	3
11	Establishment of financing mechanisms	4	0.02	1	29	0.01	1	5,674	0.04	1	0.02	3
12	Catastrophe insurance	10	0.05	1	77	0.03	1	14,895	0.11	1	0.06	19
13	Tax regulation, government subsidies, loan preferential policies	4	0.02	1	29	0.01	1	5,674	0.04	1	0.02	3

POI = points of interest.

[a] Unit: piece.

[b] Unit: CNY10,000.

Source: Authors' estimates.

Table 3: Normalized and Aggregated Results of Second Dividend

No.	Measures	Increased Business and Capital Investment	Weight	Increased Household and Agricultural Productivity	Weight	Increased Land Value from Protective Infrastructure	Weight	Increased Fiscal Stability and Access to Credit	Weight	Created Jobs	Weight	Aggregated Value	Normalized Aggregated Value
1	Wuzhou Flood Hazard Assessment and Risk Mapping Project	1	1	0	1	0	1	0	1	0	1	0.04	7
2	Wuzhou Urban Resilience Action Plan	1	1	1	1	0	1	0	1	0	1	0.08	13
3	Xijiang River Flood Control and Dike Upgrading Project	3	1	2	1	5	1	1	1	4	1	0.60	100
4	River, Lake, and Reservoir Connection Project	1	1	2	1	2	1	1	1	2	1	0.32	53
5	Wuzhou Urban Drainage and Waterlogging Comprehensive Treatment Project	1	1	1	1	3	1	1	1	2	1	0.32	53
6	Source Sponge Construction Project	2	1	1	1	2	1	1	1	3	1	0.36	60
7	Information Management and Control Platform for Urban Drainage and Flood Prevention	1	1	0	1	0	1	0	1	0	1	0.04	7
8	Urban Hydraulic Modelling Project	0	1	0	1	0	1	0	1	0	1	0	0
9	Enhancement of public participation	2	1	0	1	0	1	1	1	3	1	0.24	40
10	Participation of social groups in flood prevention and disaster reduction	1	1	0	1	0	1	0	1	2	1	0.12	20
11	Establishment of financing mechanisms	3	1	1	1	1	1	0	1	0	1	0.2	33
12	Catastrophe insurance	1	1	1	1	1	1	4	1	0	1	0.28	47
13	Tax regulation, government subsidies, loan preferential policies	1	1	1	1	1	1	2	1	0	1	0.2	33

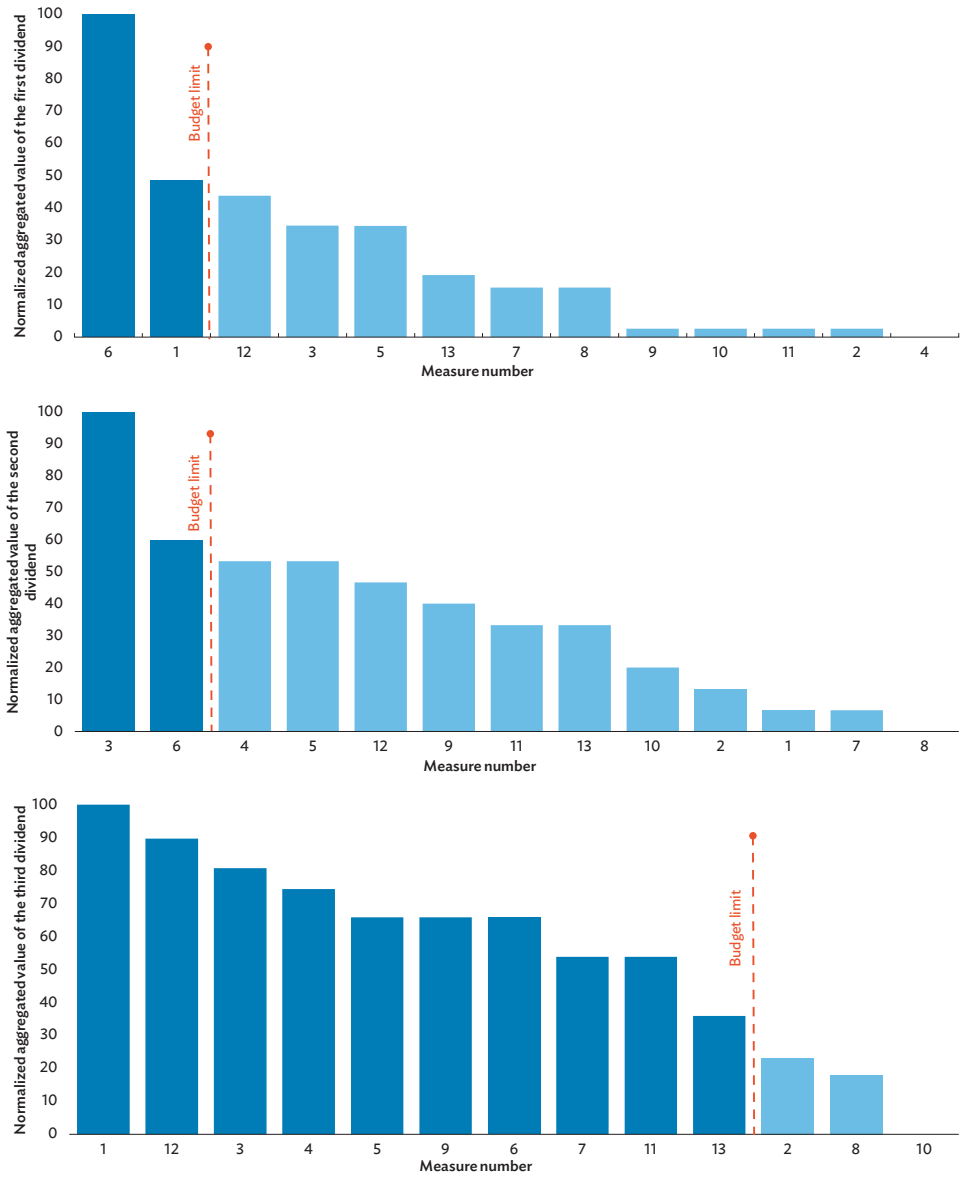
Source: Authors' estimates.

Table 4: Normalized and Aggregated Results of Third Dividend

No.	Measures	Increased Gender Equality	Weight	Enhanced Transparency	Weight	Strengthened Institutional Capacity	Weight	Increased Stakeholder Engagement	Weight	Aggregated Value	Normalized Aggregated Value
1	Wuzhou Flood Hazard Assessment and Risk Mapping Project	0	2	3	5	3	5	1	2	0.91	100
2	Wuzhou Urban Resilience Action Plan	0	2	1	5	2	5	2	2	0.76	54
3	Xijiang River Flood Control and Dike Upgrading Project	0	2	1	5	1	5	1	2	0.80	66
4	River, Lake, and Reservoir Connection Project	0	2	1	5	2	5	1	2	0.85	81
5	Wuzhou Urban Drainage and Waterlogging Comprehensive Treatment Project	0	2	2	5	3	5	2	2	0.83	74
6	Source Sponge Construction Project	0	2	2	5	1	5	4	2	0.66	23
7	Information Management and Control Platform for Urban Drainage and Flood Prevention	0	2	1	5	2	5	2	2	0.76	54
8	Urban Hydraulic Modelling Project	0	2	1	5	1	5	1	2	0.80	66
9	Enhancement of public participation	1	2	2	5	2	5	0	2	0.88	90
10	Participation of social groups in flood prevention and disaster reduction	3	2	1	5	2	5	4	2	0.58	0
11	Establishment of financing mechanisms	0	2	1	5	1	5	3	2	0.64	18
12	Catastrophe insurance	0	2	1	5	1	5	1	2	0.80	66
13	Tax regulation, government subsidies, loan preferential policies	1	2	1	5	1	5	1	2	0.70	36

Source: Authors' estimates.

Figure 3: Ranking of Measures for Each Dividend



Notes:

Measure 1: Wuzhou Flood Hazard Assessment and Risk Mapping Project

Measure 2: Wuzhou Urban Resilience Action Plan

Measure 3: Xijiang River Flood Control and Dike Upgrading Project

Measure 4: River, Lake, and Reservoir Connection Project

Measure 5: Wuzhou Urban Drainage and Waterlogging Comprehensive Treatment Project

Measure 6: Source Sponge Construction Project

Measure 7: Information Management and Control Platform for Urban Drainage and Flood Prevention

Measure 8: Urban Hydraulic Modeling Project

Measure 9: Enhancement of public participation

Measure 10: Participation of social groups in flood prevention and disaster reduction

Measure 11: Establishment of financing mechanisms

Measure 12: Catastrophe insurance

Measure 13: Tax regulation, government subsidies, loan preferential policies

Source: Authors' estimates.

Table 5: Summary of Prioritized Disaster Risk Management Interventions

Dividend	Number of Measures Within the Budget Limit	Total Cost (CNY million)	Note
1	2	574	Planned budget was CNY740 million
2	2	716	
3	10	739	

Note: The planned budget was estimated based on the Wuzhou 14th Five-Year Water Security Plan (2021–2025).

Source: Authors' estimates.

Table 6: Prioritization Criteria

Priority Level	Criteria
Priority 1	Prioritized in all three dividends
Priority 2	Prioritized in 1st and 2nd but not in 3rd dividend Prioritized in 1st and 3rd but not in 2nd dividend
Priority 3	Prioritized in 1st but not in 2nd and 3rd dividends Not prioritized in 1st but in 2nd and 3rd dividends Not prioritized in 1st nor 3rd but in 2nd dividend Not prioritized in 1st nor 2nd but in 3rd dividend
Priority 4	Not prioritized in all three dividends

Source: Asian Development Bank.

Table 7: Prioritization of Disaster Risk Management Interventions

No.	Measure	NAV Under First Dividend (%)	NAV Under Second Dividend (%)	NAV Under Third Dividend (%)	Overall Priority
1	Wuzhou Flood Hazard Assessment and Risk Mapping Project	35	7	**100**	3
2	Wuzhou Urban Resilience Action Plan	0	13	**54**	3
3	Xijiang River Flood Control and Dike Upgrading Project	**100**	**100**	**66**	1
4	River, Lake, and Reservoir Connection Project	**49**	53	**81**	2
5	Wuzhou Urban Drainage and Waterlogging Comprehensive Treatment Project	34	53	**74**	3
6	Source Sponge Construction Project	44	**60**	23	3
7	Information Management and Control Platform for Urban Drainage and Flood Prevention	15	7	**54**	3
8	Urban Hydraulic Modelling Project	15	0	**66**	3
9	Enhancement of public participation	3	40	**90**	3
10	Participation of social groups in flood prevention and disaster reduction	3	20	0	4
11	Establishment of financing mechanisms	3	33	18	4
12	Catastrophe insurance	19	47	**66**	3
13	Tax regulation, government subsidies, loan preferential policies	3	33	**36**	3

NAV = normalized aggregated value.

Notes: Figures in bold indicate associated interventions prioritized under the respective dividend.

Source: Asian Development Bank.

V. CONCLUSION AND WAY FORWARD

The purpose of this working paper is to improve awareness and mindset, facilitating a shift toward more strategic and informed disaster risk management (DRM) practices. It demonstrated that integrating DRM into development by prioritizing DRM measures based on cost-effectiveness analysis (CEA) is a sure way to build resilience to potential disasters, a cornerstone of sustainable development. Likewise, investing in DRM within development is a smart approach, yielding direct and indirect benefits for various stakeholders by building resilience to natural hazards and climate change.

The paper articulated a comprehensive view of integrated disaster risk management (IDRM) and underscored the significance of an integrated approach in DRM and the CEA. Failure to explore the full range of DRM measures can often lead to inefficient allocation of limited resources, overlooked synergies, and introduction of new threats to the development process. When examining various DRM measures, it is crucial to acknowledge their direct benefits and the co-benefits, and to prioritize these based on cost-effectiveness. Evaluating both direct and indirect benefits facilitates a more inclusive decision-making process by engaging a diverse array of stakeholders with varying priorities and perspectives. This approach can also mitigate the challenges posed by the uncertainties associated with climate change and socioeconomic development, as the inclusion of development impacts provides a critical reference point for decision-making.

The paper detailed the triple dividends of resilience, which extends the benefits of DRM investments beyond mere avoided disaster losses to include economic growth and environmental, social, and governance (ESG) benefits. This broadened perspective enhances our understanding of the multifaceted impacts of disasters and also aligns DRM with sustainable development imperatives, enhancing the adoption of DRM investments in the development field. The case study provided illustrates the application of the methodology in the decision-making process.

IDRM spans all sectors and societal levels. Effective collaboration and partnership among various stakeholders—including governments, nongovernment organizations, academia, civil society, the private sector, and international actors—is crucial. These partnerships are instrumental in pooling expertise, resources, and knowledge to craft comprehensive DRM solutions, mobilize resources for DRM initiatives, and ensure policy and operational coherence. Within government structures, efficient coordination and communication among development agencies, disaster management authorities, meteorological and seismological bureaus, and other relevant offices is vital to enhancing social disaster resilience. Inclusive stakeholder participation ensures a thorough and equitable approach to identifying benefit indicators, providing a solid foundation for decision-makers in their assessment of resilience investments.

Pushing further for an integrated approach for DRM measures based on CEA may require leveraging ADB's efforts in integrating DRM (coherent with Strategy 2030—Operational Plan for Priority 3, and the *Climate Change Action Plan, 2023–2030)* into the whole cycle of ADB's engagement with its developing member countries, running through its upstream, midstream, and downstream operations:

(i) **Upstream engagement**. Conduct country-level climate and disaster risk assessments; create and update country risk profiles and analytics; establish country risk data and information generation and exchange systems and mechanisms to enable informed decision-making; evaluate climate adaptation and disaster risk management policies and regulations; identify policy, capacity, and infrastructure gaps to effectively manage climate and disaster risks; and develop strategies for integrated disaster risk management and provision of an enabling environment for risk-informed or risk-sensitive pipeline identification.

(ii) **Midstream engagement**. Focus on institutional strengthening to enhance understanding and capacity for coordination and collaboration among all stakeholders and ensure that selection of DRM measures is cost-effective, gender-sensitive, and inclusive.
(iii) **Downstream engagement**. Ensure staff possess the understanding, capacity, and know-how to design and implement high-quality climate and DRM projects.

To achieve the way forward, it is practical to organize a 2- to 3-day intensive country programming training session to focus on why and how to address development issues using an IDRM approach. The approach will align with ADB strategies, operation plans, and guidelines related to resilience to disaster and climate change, cost-effective investment, and gender equality and social inclusion. The training can be well supported by lessons learned in previous ADB programs and operations and good international practices.

In conclusion, as the world faces increasing uncertainties due to climate change and socioeconomic shifts, the principles and methodology outlined in this paper provide a low-regret approach in the decision-making process for DRM investment, thereby enhancing DRM's effectiveness. The application of the outlined approach in the real-world decision-making process may face various challenges, including data availability, willingness for innovation, and institutional silos, which can vary greatly depending on the level of sophistication. Addressing these challenges is a collective endeavor and is crucial for building resilient infrastructures and communities equipped to adapt to, and thrive in the face of, inevitable future challenges.

Appendix 1: Metrics for Evaluating the Benefit Indicators of Disaster Risk Management Interventions and Their Linkage to Global Agendas

Dividend Category	Benefit Indicators	Metrics	SFDRR Indicators	SDG Targets	PCA Articles
First Dividend: Avoided Damage and Losses	1.1 Avoided loss of life or saved lives	Number of lives saved	Target A1-3	G1/T1.5.1; G3/T3.2; G11/T11.5.1; G13	Article 7
	1.2 Reduced number of people affected	Reduction in number of affected people who suffered from physical injury, illness, or other direct losses, as well as those affected in terms of economic impact, e.g., loss of workdays, reduced health-care costs, or avoided property damage	Target B1-5	G1/T1.5.1; G11/T11.5.1; G13/T13.1.2	Article 7
	1.3 Reduced damage to assets	Difference in the expected physical damage to assets with and without a particular intervention expressed in monetary terms; includes asset value, replacement or repair cost, and indirect costs such as loss of functionality	Target D1-8	G9; G11; G12	Indirectly linked (Article 7)
	1.4 Reduced loss to economic flows	Avoided economic losses in monetary terms	Target C1-6	G1/T1.5.2; G8/T8.3; G11/T11.5.2	Indirectly linked
	1.5 Reduced functional losses to essential services	Reduced functional losses to essential services such as service availability and continuity, capacity and performance, user impact and satisfaction, economic impacts, health and safety outcomes, and response time for emergency services	Target D	G3/T3.8; G6/T6.1; G9/T9.1; G11/T11.5 and T11.b	Article 7
Second Dividend: Unlocking Economic Potential	2.1 Increased business and capital investment	The additional amount of money that business and investors are willing to invest in monetary terms	Highlighted in Priority 3; Indirectly Target D	G8/T8.3; G9/T9.3	Implicitly linked to the PCA objectives

continued on next page

Appendix 1 *continued*

Dividend Category	Benefit Indicators	Metrics	SFDRR Indicators	SDG Targets	PCA Articles
	2.2 Increased household and agricultural productivity	The additional value of output produced per unit of input by households and agricultural activities, measured in terms of income or time saved for household productivity and in terms of yield or value per unit area for agricultural productivity	Highlighted in Priority 3	G1/T1.5; G2/T2.3	Fundamental priority for food security
	2.3 Increased land value from protective infrastructure	The increased value of land from protective infrastructure expressed in monetary terms per unit area	Indirectly Target D	G11/T11.B; G9/T9.1	Indirectly linked (Article 7.1)
	2.4 Increased fiscal stability and access to credit	Sovereign risk ratings, credit scores, interest rates, asset quality ratios, and profitability	Indirect contribution	G1/T1.4; G8/T8.10	Indirectly linked
	2.5 Created jobs	Total number of new jobs created directly and indirectly in raw numbers and normalizable per unit of investment	Not explicitly mentioned, but crucial to strengthening economic resilience	G8/T8.5	Implicitly Article 2.1(a); Article 6
Third Dividend: Generating Development Co-benefits	3.1 Improved environmental quality	Various metrics for measuring environmental quality indicators such as air quality, water quality, soil quality, ecosystem health	Highlighted importance of environment-related factors	G3/T3.9; G11/T11.6	Implicit objective
	3.2 Improved water conservation	Total amount of water used, intensity of water use relative to some other factors, efficiency of a given amount of water use, and the amount of water saved	One of the guiding principles	G6/T6.4	Indirectly linked
	3.3 Improved biodiversity conservation	Species richness, evenness, or diversity indices; Living Planet Index; Biodiversity Intactness Index; Protected Area Coverage; Red List Index; Species Habitat Index	One of the guiding principles	G15/T15.5	Indirectly linked

continued on next page

Appendix 1 *continued*

Dividend Category	Benefit Indicators	Metrics	SFDRR Indicators	SDG Targets	PCA Articles
	3.4 Reduced carbon emission	Metric tons of carbon dioxide equivalent	Not explicitly mentioned	G13/T13.2	Article 4
	3.5 Enhanced community cohesion and social capital	Social network density, participation in community activities, trust level, availability and effectiveness of community support structures for vulnerable population, ability of the community to main functional social structures	Target B; indirect contribution to Targets D and E	G11, G3, G16	Articles 7 and 8
	3.6 Improved health outcomes	Mortality rate, years of life lost, years lived with disability, disability-adjusted life years, quality-adjusted life years, health life years, self-reported health status	Implicitly highlighted in Priority 4	G3/T3.1; G3/T3.2; G3/T3.3	Article 7
	3.7 Enhanced development sustainability	Economic growth rates, resource efficiency, environmental impacts, social inequality indices, access to basic services, investment in renewable energy	Target C; indirect contribution to Targets D and E	G9, G11, G12, G13	Articles 4 and 7
	3.8 Increased education opportunities	Enrollment rates, completion rates, literacy rates, average years of schooling, learning outcomes, education quality indicators	Priority 1	G4/T4.7	Highlighted importance of public access to information
	3.9 Increased gender equality	Gender Development Index, Gender Empowerment Measure, Gender Inequality Index, Gender Wage Gap, Proportion of Women in Leadership Roles	Highlighted gender equality in all policies and practices	G1/T1.b; G4/T4.5, 4.7; G5/T5.c	Highlighted importance of gender responsiveness

continued on next page

Appendix 1 *continued*

Dividend Category	Benefit Indicators	Metrics	SFDRR Indicators	SDG Targets	PCA Articles
	3.10 Strengthened institutional capacity	Institutional Capacity Index, Worldwide Governance Indicators, Public Administration Performance Index, Country Policy and Institutional Assessment	Priority 2	G16/T16.A	Article 11
	3.11 Enhanced transparency	Transparency International's Corruption Perceptions Index, Open Budget Index, Global Right to Informational Rating	One of the guiding principles	G16/T16.6	Article 13
	3.12 Enhanced stakeholder engagement	Stakeholder Engagement Assessment Matrix, Accountability's AA1000 Stakeholder Engagement Standards, Stakeholder Participation Score	Target F1-8	G17/T17.16	Highlighted importance of stakeholder engagement

PCA = Paris Climate Agreement, SDG = Sustainable Development Goal, SFDRR = Sendai Framework for Disaster Risk Reduction.

Source: Asian Development Bank.

Appendix 2: Summary of the Most Relevant Benefit Indicators for Typical Integrated Disaster Risk Management Interventions

Intervention	Indicators		
	First Dividend	Second Dividend	Third Dividend
1. Hazard Mitigation			
1.1 Structural hazard mitigation measures	(i) Avoided loss of life (ii) Reduced number of people affected (iii) Reduced damage to assets (iv) Reduced functional losses to essential services (v) Reduced loss to economic flows	(i) Increased land value from protective infrastructure (ii) Created jobs (iii) Increased business and capital investment (iv) Increased fiscal stability and access to credit	(i) Improved health outcomes (ii) Enhanced development sustainability (iii) Reduced carbon emission (iv) Strengthened institutional capacity (v) Enhanced community cohesion and social capital

continued on next page

Appendix 2 *continued*

Intervention	Indicators		
	First Dividend	Second Dividend	Third Dividend
1.2 Critical infrastructure protection measures	(i) Reduced damage to assets (ii) Reduced functional losses to essential services (iii) Reduced loss to economic flows (iv) Avoided loss of life (v) Reduced number of people affected	(i) Increased land value from protective infrastructure (ii) Created jobs (iii) Increased business and capital investment (iv) Increased fiscal stability and access to credit	(i) Strengthened institutional capacity (ii) Enhanced development sustainability (iii) Improved health outcomes (iv) Enhanced transparency (v) Enhanced stakeholder engagement
1.3 Ecosystem conservation including green infrastructure	(i) Reduced damage to assets (ii) Reduced functional losses to essential services (iii) Reduced loss to economic flows (iv) Reduced number of people affected	(i) Increased land value from protective infrastructure (ii) Created jobs (iii) Increased business and capital investment (iv) Increased fiscal stability and access to credit	(i) Improved environmental quality (ii) Improved water conservation (iii) Increased biodiversity conservation (iv) Reduced carbon emission (v) Enhanced community cohesion and social capital
1.4 Reforestation and afforestation	(i) Reduced damage to assets (ii) Reduced functional losses to essential services (iii) Reduced loss to economic flows (iv) Reduced number of people affected	(i) Increased land value from protective infrastructure (ii) Created jobs (iii) Increased business and capital investment (iv) Increased fiscal stability and access to credit	(i) Improved environmental quality (ii) Improved water conservation (iii) Increased biodiversity conservation (iv) Reduced carbon emission (v) Enhanced community cohesion and social capital
1.5 Erosion control	(i) Reduced damage to assets (ii) Reduced functional losses to essential services (iii) Reduced loss to economic flows (iv) Reduced number of people affected	(i) Increased household and agricultural productivity (ii) Increased land value from protective infrastructure (iii) Increased business and capital investment (iv) Created jobs (v) Increased fiscal stability and access to credit	(i) Improved environmental quality (ii) Improved water conservation (iii) Improved biodiversity conservation (iv) Enhanced development sustainability (v) Enhanced institutional capacity

continued on next page

Appendix 2 *continued*

2. Exposure Control (Assets and People)			
2.1 Land-use planning and zoning	(i) Reduced damage to assets (ii) Reduced functional losses to essential services (iii) Reduced loss to economic flows (iv) Reduced number of people affected	(i) Increased land value from protective infrastructure (ii) Increased business and capital investment (iii) Created jobs (iv) Increased fiscal stability and access to credit	(i) Enhanced development sustainability (ii) Improved environmental quality (iii) Strengthened institutional capacity (iv) Enhanced community cohesion and social capital (v) Enhanced transparency
2.2 Relocation of critical assets and people	(i) Avoided loss of life (ii) Reduced number of people affected (iii) Reduced damage to assets (iv) Reduced functional losses to essential services	(i) Increased land value from protective infrastructure (ii) Increased fiscal stability and access to credit (iii) Created jobs (iv) Increased business and capital investment	(i) Enhanced community cohesion and social capital (ii) Improved health outcomes (iii) Enhanced development sustainability (iv) Strengthened institutional capacity (v) Enhanced transparency
2.3 Hazard forecasting and early warning systems	(i) Avoided loss of life (ii) Reduced number of people affected (iii) Reduced damage to assets (iv) Reduced functional losses to essential services	(i) Increased land value from protective infrastructure (ii) Increased fiscal stability and access to credit (iii) Created jobs (iv) Increased business and capital investment	(i) Enhanced community cohesion and social capital (ii) Improved health outcomes (iii) Strengthened institutional capacity (iv) Enhanced transparency (v) Enhanced stakeholder engagement
3. Vulnerability Reduction (Assets and People)			
3.1 Facility and infrastructure retrofits	(i) Avoided loss of life (ii) Reduced damage to assets (iii) Reduced functional losses to essential services (iv) Reduced loss to economic flows	(i) Increased land value from protective infrastructure (ii) Created jobs (iii) Increased business and capital investment (iv) Increased fiscal stability and access to credit	(i) Reduced carbon emissions (ii) Enhanced development sustainability (iii) Improved environmental quality (iv) Strengthened institutional capacity (v) Enhanced transparency
3.2 Enhancement of building codes and standards	(i) Avoided loss of life (ii) Reduced damage to assets (iii) Reduced functional losses to essential services (iv) Reduced loss to economic flows	(v) Increased land value from protective infrastructure (vi) Created jobs (vii) Increased business and capital investment (viii) Increased fiscal stability and access to credit	(i) Enhanced development sustainability (ii) Reduced carbon emission (iii) Improved health outcomes (iv) Strengthened institutional capacity (v) Enhanced transparency

continued on next page

Appendix 2 *continued*

3. Vulnerability Reduction (Assets and People)			
3.3 Public awareness, education campaign, and local knowledge	(i) Avoided loss of life (ii) Reduced number of people affected (iii) Reduced loss to economic flows	(i) Created jobs (ii) Increased business and capital investment (iii) Increased fiscal stability and access to credit	(i) Increased education opportunities (ii) Enhanced community cohesion and social capital (iii) Strengthened institutional capacity (iv) Enhanced transparency (v) Enhanced stakeholder engagement
3.4 Shock-responsive social protection	(i) Reduced number of people affected (ii) Reduced loss to economic flows (iii) Avoided loss of life	(i) Increased fiscal stability and access to credit (ii) Created jobs (iii) Increased household and agricultural productivity	(i) Improved health outcomes (ii) Enhanced community cohesion and social capital (iii) Strengthened institutional capacity (iv) Increased education opportunities (v) Enhanced transparency
4. Resilience Strengthening (System)			
4.1 Integrated risk information and knowledge system	(i) Reduced damage to assets (ii) Reduced functional losses to essential services (iii) Reduced loss to economic flows (iv) Avoided loss of life	(i) Increased business and capital investment (ii) Increased fiscal stability and access to credit (iii) Created jobs (iv) Increased land value from protective infrastructure	(i) Strengthened institutional capacity (ii) Enhanced transparency (iii) Enhanced stakeholder engagement (iv) Enhanced community cohesion and social capital (v) Improved health outcomes
4.2 Integrated disaster risk management (DRM) and resilience strategies and action plans	(i) Avoided loss of life (ii) Reduced number of people affected (iii) Reduced damage to assets (iv) Reduced functional losses to essential services (v) Reduced loss to economic flows	(i) Increased land value from protective infrastructure (ii) Increased fiscal stability and access to credit (iii) Created jobs (iv) Increased business and capital investment	(i) Strengthened institutional capacity (ii) Enhanced community cohesion and social capital (iii) Improved health outcomes (iv) Enhanced development sustainability (v) Enhanced transparency
4.3 Mainstreaming DRM into development processes and institutions	(i) Reduced damage to assets (ii) Reduced functional losses to essential services (iii) Reduced loss to economic flows (iv) Avoided loss of life	(i) Increased land value from protective infrastructure (ii) Increased fiscal stability and access to credit (iii) Created jobs (iv) Increased business and capital investment	(i) Enhanced development sustainability (ii) Strengthened institutional capacity (iii) Enhanced transparency (iv) Enhanced stakeholder engagement (v) Improved health outcomes

continued on next page

Appendix 2 *continued*

4. Resilience Strengthening (System)						
4.4 Disaster preparedness and emergency management	(i) (ii) (iii) (iv) (v)	Avoided loss of life Reduced number of people affected Reduced damage to assets Reduced functional losses to essential services Reduced loss to economic flows	(i) (ii) (iii) (iv)	Increased land value from protective infrastructure Created jobs Increased fiscal stability and access to credit Increased business and capital investment	(i) (ii) (iii) (iv) (v)	Improved health outcomes Strengthened institutional capacity Enhanced community cohesion and social capital Enhanced transparency Enhanced stakeholder engagement
4.5 Collaboration and partnership	(i) (ii) (iii) (iv)	Reduced damage to assets Reduced functional losses to essential services Reduced loss to economic flows Reduced number of people affected	(i) (ii) (iii) (iv)	Increased business and capital investment Created jobs Increased fiscal stability and access to credit Increased land value from protective infrastructure	(i) (ii) (iii) (iv) (v)	Enhanced community cohesion and social capital Strengthened institutional capacity Enhanced stakeholder engagement Enhanced transparency Enhanced development sustainability
4.6 Community-based DRM	(i) (ii) (iii) (iv)	Avoided loss of life Reduced number of people affected Reduced damage to assets Reduced functional losses to essential services	(i) (ii) (iii) (iv)	Increased land value from protective infrastructure Created jobs Increased fiscal stability and access to credit Increased business and capital investment	(i) (ii) (iii) (iv) (v)	Enhanced community cohesion and social capital Improved health outcomes Strengthened institutional capacity Enhanced transparency Enhanced stakeholder engagement
4.7 Ecosystem-based adaptation	(i) (ii) (iii) (iv)	Reduced damage to assets Reduced functional losses to essential services Reduced loss to economic flows Reduced number of people affected	(i) (ii) (iii) (iv)	Increased land value from protective infrastructure Increased business and capital investment Created jobs Increased household and agricultural productivity	(i) (ii) (iii) (iv) (v)	Improved environmental quality Improved water conservation Improved biodiversity conservation Enhanced development sustainability Enhanced community cohesion and social capital
4.8 Green agriculture	(i) (ii) (iii) (iv)	Reduced damage to assets Reduced functional losses to essential services Reduced loss to economic flows Reduced number of people affected	(i) (ii) (iii) (iv)	Increased household and agricultural productivity Increased business and capital investment Created jobs Increased fiscal stability and access to credit	(i) (ii) (iii) (iv) (v)	Improved environmental quality Improved water conservation Improved biodiversity conservation Reduced carbon emission Enhanced development sustainability

continued on next page

Appendix 2 *continued*

4. Resilience Strengthening (System)			
4.9 Support to micro, small, and medium-sized enterprises	(i) Reduced loss to economic flows (ii) Reduced damage to assets (iii) Reduced functional losses to essential services (iv) Reduced number of people affected	(i) Increased business and capital investment (ii) Created jobs (iii) Increased fiscal stability and access to credit (iv) Increased household and agricultural productivity	(i) Enhanced development sustainability (ii) Increased educational opportunities (iii) Increased gender equality (iv) Strengthened institutional capacity (v) Enhanced stakeholder engagement
4.10 Climate and/or disaster risk financing	(i) Reduced damage to assets (ii) Reduced functional losses to essential services (iii) Reduced loss to economic flows (iv) Reduced number of people affected	(i) Increased fiscal stability and access to credit (ii) Increased business and capital investment (iii) Created jobs (iv) Increased land value from protective infrastructure	(i) Enhanced development sustainability (ii) Improved health outcomes (iii) Strengthened institutional capacity (iv) Enhanced transparency (v) Enhanced stakeholder engagement
4.11 Post-disaster recovery strategy and action plan	(i) Reduced damage to assets (ii) Reduced functional losses to essential services (iii) Reduced loss to economic flows (iv) Reduced number of people affected	(i) Created jobs (ii) Increased business and capital investment (iii) Increased fiscal stability and access to credit (iv) Increased household and agricultural productivity (v) Increased land value from protective infrastructure	(i) Improved health outcomes (ii) Enhanced development sustainability (iii) Strengthened institutional capacity (iv) Enhanced transparency (v) Enhanced stakeholder engagement

Source: Asian Development Bank.

Integrated Approach for Cost-Effective Disaster Risk Management

This working paper outlines the critical interconnections between disasters, climate change, and development, emphasizing the necessity for a proactive and integrated approach to disaster risk management to mitigate the adverse impacts of natural hazards and support sustainable development. It highlights the ongoing shift in disaster management paradigms—from reactive responses to proactive, integrated risk management approaches that engage multiple sectors and stakeholders.

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.

ADB

ASIAN DEVELOPMENT BANK
6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
www.adb.org