Identification of Climate Resilience Opportunities and Metrics in Financing Operations:

A technical reference document for IDB project teams

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IDB
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Why do we need to focus on climate resilience elements and metrics in our projects? Where do we start?

There is a general consensus that the work on adaptation and climate resilience has to be prioritized and that development operations must be consistent with countries' climate-resilient development pathways in line with the Paris Agreement. Current adaptation and climate resilience actions are not sufficient, both in scope and ambition, in light of the increased occurrence of slow- and rapid-onset climate-related shocks[1] and stresses, and they lack the necessary integration to guarantee a well-planned adaptation process across sectors and government levels.

Since the first international agenda on adaptation was launched by the United Nations (UN)[2] in 1999-2000, many countries around the globe have generated National Communications (NCs) to the United Nations Framework Convention on Climate Change (UNFCCC). These have been key planning documents that identify vulnerable systems at the national level and define priorities for each country in terms of mitigation and adaptation. There has been a clear evolution in the global adaptation agenda, starting at the 1996 United Nations Climate Change Conference (second Conference of the Parties (COP2)) and through COP26 in 2021, which is currently in preparation. The adaptation roadmap developed at the COPs contains many milestones that, as in the case of NCs, have helped countries build national adaptation agendas. Lately, the development of long-term adaptation strategies has been gaining traction and many countries have started to recognize these as necessary instruments for sustainable adaptation and climate resilience action in line with the requirements of the Paris Agreement.

Lessons learned from the COPs and experiences from implemented projects in the field throughout the last decade have been instrumental for establishing a universally recognized iterative process to enhance climate-change adaptation that involves four core steps, namely (i) assess climate-change impacts, vulnerability, climate change-related risks, and climate resilience, (ii) plan for climate-change adaptation, (iii) implement respective adaptation measures, and (iv) monitor and evaluate climate-change adaptation results. Although significant work has been carried out in the first two steps, implementing adaptation measures across development projects, beyond specific adaptation activities, and monitoring and evaluation (M&E) of achieved results are still lagging behind. Additional work is required to help countries and financing institutions to systematically consider climate-change adaptation and resilience in development projects and to monitor and evaluate results.

Therefore, it should be a priority to create a common understanding and enhance knowledge on climate resilience, on how to incorporate climate resilience elements into projects, and how to define climate resilience metrics that are fit-for-purpose and context-specific. It will be essential to establish monitoring systems at the national level that integrate the work from different institutions and financiers in order to track advancements on adaptation and climate resilience.

Collecting data for climate resilience indicators over the years will help countries determine which specific activities effectively and efficiently contribute to reducing vulnerability to climate change and building adaptive capacity across regions, sectors, and types of reduced risks.

[1]In the following, climate shock will refer to a rapid or slow-onset impact of climate change
[2]Through the UN *Subsidiary Body for Scientific and Technological Advice* and the *Subsidiary Body for Implementation*

While many countries are still working on establishing systems to track and monitor climate adaptation actions and results, many of the Climate Funds around the globe have recognized the importance of this task and have developed specific results frameworks based on their own adaptation/climate resilience metrics. Unfortunately, there is neither common agreement on what constitutes a “climate resilience indicator,” nor a set of common indicators that could be used interchangeably across sectors or countries. Unlike mitigation, adaptation and climate resilience actions and metrics are very specific to the local vulnerability context.

That being said, this document aims to (1) lay the conceptual foundations to seize climate resilience opportunities in development projects by presenting definitions and examples for climate resilience elements and capacities as a basis for a climate resilience metrics framework and (2) guide sectoral specialists in identifying adequate metrics to monitor and evaluate the effectiveness of implemented adaptation and climate resilience activities via climate resilience output and outcome indicators at the project level.

Summary of the proposed conceptual approach to climate resilience and related metrics

We define climate resilience as the ability of households, communities, and systems to anticipate, absorb, and recover from weather shocks and slow-moving changes, and to positively adapt and transform in the face of long-term stresses, change, and uncertainty induced by climate change.

We focus on two climate resilience capacities that we want to strengthen through IDB projects:

1. Absorptive capacity, the capacity to reduce losses resulting from extreme weather events and/or slow-moving changes by taking actions *ex ante* and

2. Restorative capacity, the capacity to recover from losses and damages that result from extreme weather events and/or slow-moving changes by taking actions *ex post*, including "building back better,"

both of which can have a transformative dimension, to create a fundamentally new system through a systemic shift.

We consider a number of climate resilience elements, and related sub-elements, when looking at how to incorporate climate resilience into a financing operation and how to "capture" a project's contribution to building climate resilience:

Resilience element	Definition
Protection	Extent of protection against damage or harm from climate-related shocks or stresses
Robustness	Ability of infrastructure, ecosystem, community, system, etc. to withstand the impacts of shocks and fluctuations and to maintain its characteristics, performance, and functions in the face of a crisis
Preparedness	Ability to manage and cope with climate-related shocks or stresses Preparedness includes the following sub-elements: ***Modularity,*** the degree to which a system's components may be separated and recombined, facilitating recovery after a climate shock and ability to adapt to future climatic changes ***Managing slow variables and feedback***, the ability to identify key slow-changing climatic variables and responses that help to identify critical thresholds, maintain system functioning, as well as to offset the negative impacts of these changes ***Learning/awareness***, the ability tto generate feedback, gain or create knowledge, provide information for decision-making, and build the skills, attitudes, and competencies needed to innovate and adapt to change
Recovery	Ability to recover from climate-related shocks and emergencies Recovery includes the following sub-elements: ***Reparability,*** the ability to repair something that was damaged ***Reconstruction***, the ability to rebuild something that was damaged or destroyed ***Building Back Better***, the extent to which risks of future climate-related shocks and disasters are reduced through the integration of risk-reduction measures into restoration, reconstruction, or the construction of new infrastructure
Diversification	Extent to which assets or activities are distributed, allocated or varied in a way that reduces exposure to risks and balances losses under different adverse scenarios
Redundancy	Availability of additional/spare/backup resources or capacity that can be accessed in the case of shocks or in the event of disruptions and that help withstand failure and ensure continuity of services
Integration/ Connectedness	Degree to which climate resilience is integrated across the system/Breadth of resources and structures that can be accessed, at multiple levels, in order to respond or adapt to shocks or stressors Integration/Connectedness includes the following sub-elements: ***Polycentric governance systems,*** the extent to which multiple governing bodies interact in a governance system to make and enforce rules ***Complex adaptive systems thinking,*** the extent to which the complex interactions and dynamics between actors and systems are considered
Flexibility	Ability to respond to uncertainty associated with climate change and disaster risk, to address challenges, and to utilize the opportunities that may arise from change Flexibility includes **Options** as a sub-element, the ability to choose between different alternatives

Illustrative list of climate resilience output and outcome indicators:

Sector	Climate resilience output metrics:	Related climate resilience outcome metrics:
Agriculture	# of rural service providers that integrate high-quality agro-climatic data (learning, preparedness) into service provision and provide access to this data # of provincial staff trained in topics related to climate change preparedness, integration/ connection, complex adaptive systems thinking, and recovery	Actual or expected reduction in avoided losses in crop yield and livestock of farmers when exposed to a climatic shock, due to access to and use of high quality agro-climatic data (reduced losses) Reduction in production losses in dry/drought years due to enhanced capacities of provincial institutions (reduced losses) Reduction in time and costs required for repair and recovery measures due to enhanced capacities at provincial institutions (increased coping ability)
Natural Resource Management	# of forest restoration campaign material sections detailing the link between sustainable forest management and resilience elements (learning, robustness, protection) # of hectares where sustainable forest management practices are applied (robustness) Documentation of mechanisms in the pest monitoring and forest restoration system that allow for data sharing (learning) and integrated emergency response plans (preparedness) # of institutions that use data sharing mechanisms in the monitoring of pests and the restoration of forest systems (learning, preparedness)	Reduced forest density loss due to climate shocks or climate-related pests (reduced losses) Reduction in the size of bark beetle outbreaks throughout the country after extreme climate event (increased coping ability)
Energy	# of applied updated technical standards, such as network codes or procurement criteria, that address robust and protected energy infrastructure # of energy infrastructure design documents with sections that specifically address redundancies and reparability of infrastructure	Reduction in the # of days with disruptions to energy services from climate shocks due to updated technical standards (reduced losses) Fewer days to repair damaged infrastructure caused by climate shock due to restorative elements in infrastructure design (increased coping ability)
Fiscal Policy and Management	# of public sector entities that invest in absorptive resilience elements (e.g., robustness and protection) Increase in value/share of budget allocated to investments to integrate response to climatic shocks, more timely recovery, and redundancies	Reduced physical damage resulting from climatic shocks to public infrastructure because of higher investments in resilience (reduced losses) Fewer days to restore public service provision and private operations after climatic shocks due to higher investments in resilience from public budget allocation (increased coping ability)
Housing and Urban Development	# of city planning documents and land-use zoning documents that address climatic conditions to increase robustness and protection Design documents of public spaces that adhere to climate resilience-related building codes and design standards, e.g., incorporating reparability and options to recover in the case of a climatic event	Fewer people harmed/fewer # of structures damaged or collapsed during an extreme event due to consideration of climatic conditions in planning and zoning documents (reduced losses) Fewer days to repair damages after climate shocks due to adherence to building codes and design standards (increased coping ability)
Transport	# of operational mechanisms to ensure protection and robustness of logistics systems regarding climatic events and stressors # of sections in rehabilitation / maintenance documents integrating climate considerations to reduce time/expenses for repairs of urban and inter-urban transportation systems (enhances preparedness, reparability, reconstruction, and recovery)	Reduced physical damage to logistics systems caused by climatic shocks due to operational mechanisms (reduced losses) Reduced # of days to restore transport / logistics systems after climatic events due to climate considerations in rehabilitation / maintenance documents (increased coping ability)
Water and Sanitation	# of technologies adopted and operationalized to reduce non-revenue water, increasing preparedness and robustness of service provision in light of increasing water scarcity # of system-wide Integrated Water Resources Management (IWRM) plans implemented that specifically address redundancies, recovery capacity, options for recovery, and reparability	Reduction in income lost from water service outages caused by exposure to climate shocks (reduced losses) Fewer days to restore system-wide water services disrupted by climate shocks due to restorative considerations in IWRM plans (increased coping ability)

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Acronyms

AUP	Adaptive urban planning
AIT	Average Interruption Time
ASAI	Average Service Availability Index
CCS	IDB Climate Change Division
COP	Conference of the Parties
CRF	Corporate Results Framework
CS	Country Strategy
DRA	Disaster Risk Assessment
DRMP	Disaster Risk Management Plan
ESG	IDB Environmental and Social Solutions Unit
ESPF	IDB Environmental and Social Policy Framework
EU-CIRCLE	European Union Critical Infrastructure Resilience Platform
GHG	Greenhouse gas
GIS	Geographic information system
IDB	Inter-American Development Bank
IDBG	IDB Group
IDFC	International Development Finance Club

Acronyms

IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
LAC	Latin America and the Caribbean
MDBs	Multilateral Development Banks
M&E	Monitoring & Evaluation
NAP	National Adaptation Plans
NBS	Nature-based solutions
NC	National Communication
NDC	Nationally Determined Contribution
OECD	Organization for Economic Co-operation and Development
OP	Operational Policy
PCR	Project Completion Report
PMR	Project Monitoring and Reporting
PP	Project Profile
SAIDI	System Average Interruption Duration Index
SFD	Sector Framework Document
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations Office for Disaster Risk Reduction
VPC	IDB Vice Presidency of Countries
VPS	IDB Vice Presidency of Sectors

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1. Introduction

1.1 Context and background

1. The region of Latin America and the Caribbean (LAC) is highly vulnerable to the effects of climate change, which include, amongst others, sea-level rise, natural disasters, changing precipitation and temperature patterns, with respective negative impacts on livelihoods, health, productivity, infrastructure, and food security. To further reduce poverty and inequality and to ensure sustainable growth in the LAC region, it will be essential to reduce climate change-related losses and increase coping ability. Consequently, the Inter-American Development Bank (IDB) strives to contribute to enhancing climate resilience in the LAC region by (1) considering climate risks and needs for adaptation and climate resilience at the (sub-)national, sector, and project level, ensuring that IDB projects across sectors are resilient to climate change and disasters, and (2) promoting more projects and project components that explicitly aim at building climate resilience. As a basis for this, principles, criteria, and tools are needed to incorporate climate resilience elements throughout the project cycle and to define fit-for-purpose metrics to track climate resilience outputs and outcomes at the project level

2. National Communications (NCs) to the UNFCCC and the adaptation roadmap developed at the COPs have helped countries build national adaptation agendas. Lately, the development of long-term adaptation strategies has been gaining traction, and many countries have started to recognize these as necessary instruments for sustainable adaptation and climate resilience action in line with the requirements of the Paris Agreement. Lessons learned from climate-change

mainstreaming work around the globe during the last decade indicate that the most effective path towards enhancing climate resilience at the project-level is systematically incorporating climate-change and disaster risks into the planning and design processes across sectors (upstream). At the IDB, this is supported by internal "pipeline scanning" conducted by the Climate Change Division, as well as by screening for environmental and climate-related risks conducted by the Environmental and Social Safeguards Division. The latter process uses the IDB's *Disaster and climate risk assessment methodology for IDB projects,* which facilitates the process for the identification and assessment of climate change and disaster risks and provides guidance for the identification of resilience opportunities in relevant projects, mostly medium and high risk, during project identification, preparation, and implementation. In addition, the IDB also counts on sector specific tools to support adaptation efforts (e.g., the DMDU (decision making under deep uncertainty) guidebook for transportation planning under a changing climate (Lempert et al. 2021), *Sustainable infrastructure framework* (IDBG 2018), and methodology to assess adaptive capacity in the water sector (Allen et al. 2020)).

3. Many IDB member countries are currently working on improving the adaptation chapters of their Nationally Determined Contributions (NDCs) and/or National Adaptation Plans (NAP), which requires the identification and prioritization of specific investments in long-term adaptation and/or climate resilience and the development of vulnerability assessments and related baselines at the sector or geographical levels. To help these countries achieve their long-term goals in adaptation and climate resilience, IDB investments need to consistently design activities that enhance climate resilience using pre-determined baselines. The results of these investments then need to be tracked and measured via context-specific and fit-for-purpose output and outcome indicators at the project level.

4. Climate resilience metrics are also needed to demonstrate progress and align financing flows with the climate resilience goals of the Paris Agreement.[3] IDB, alongside other multilateral development banks (MDBs), is committed to aligning operations with the objectives of the Paris Agreement, making projects more climate-resilient, and supporting clients and their communities in adapting to the adverse impacts of climate change.[4] In the technical paper *A framework and principles on climate resilience metrics in financing operations* (African Development Bank et al. 2019), MDBs and members of the IDFC set out principles and a framework for such metrics as a basis for institution-specific climate resilience metrics systems in line with the joint commitment of MDBs and the IDFC of the *2017 One Planet Summit* to develop a common framework for tracking progress towards achieving resilience.[5]

1.2 Objective of this document

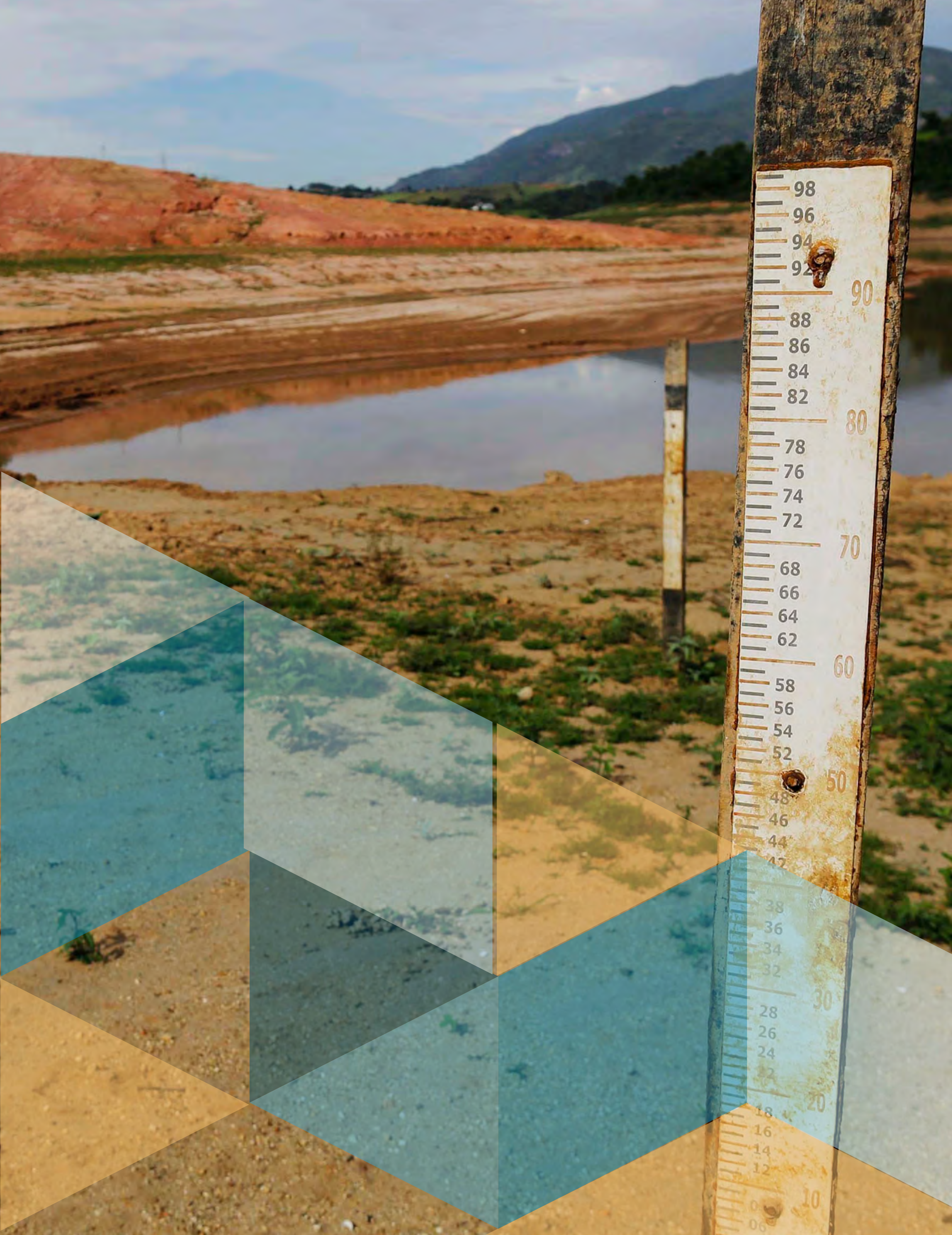
5. Given the urgent and increasing need to invest more in adaptation and climate resilience-related measures in the member countries that the IDB serves and the need to monitor and to evaluate the success of these measures in reducing vulnerability to climate variability and change, the objective of this document is to provide orientation

[3] December 2015 Paris Agreement.
[4] December 2018 COP24 - Joint MDB declaration regarding alignment approach to the objectives of the Paris Agreement.
[5] December 2017 One planet summit - Joint IDFC-MDB statement.

for IDB project teams from different sectors on how to identify climate resilience opportunities and define respective indicators at project level to facilitate the monitoring and assessment of how these projects have contributed to enhancing climate resilience.

6. The framework presented in this document was developed within the IDB in 2018. It has been socialized within a number of divisions within the IDB Group (IDBG), including IDB-Invest, and tested in several sectors, namely agriculture and natural resources management, energy, fiscal policy and management, housing and urban development, transport, and water and sanitation. Operationalizing this framework will require that relevant IDB projects define clear baselines and timelines, achievable targets, and a combination of climate resilience indicators that effectively and collectively capture how climate resilience is being built at the project level. These indicators will be linked to two specific resilience capacities, ***absorptive capacity*** and ***restorative capacity*****,** both of which can have a ***transformational dimension.*** Thinking in terms of these climate resilience capacities and related climate resilience elements will allow sector divisions within the IDB to define appropriate climate resilience indicators and track results and progress in building climate resilience.

7. **This document (1) lays the conceptual foundations to seize climate resilience opportunities in development projects** by presenting definitions and examples of climate resilience elements and capacities **and (2) facilitates the development and monitoring of climate resilience output and outcome indicators at project-level** through a conceptual qualitative climate resilience metrics framework.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2.

Approach to operationalizing climate resilience at the IDB: seizing climate resilience opportunities and monitoring results

8. In the last decade, MDBs around the world have been consistently tracking financial resources for mitigation and adaptation actions. These climate finance figures have been published in the annual MDB Climate Finance Tracking Reports[6]. These reports are an important tool for the international community to track climate finance resources allocated to different countries. In the past few years, the interest in and demand from international actors around the globe increased for MDBs to ramp up their adaptation efforts and monitor not only adaptation (and mitigation) finance inputs, but also the results of these activities. As a consequence, individual MDBs have started developing guidance on incorporating climate resilience into projects and setting up systems that will allow MDBs to identify, prioritize, and internally track specific indicators for climate resilience at project level.

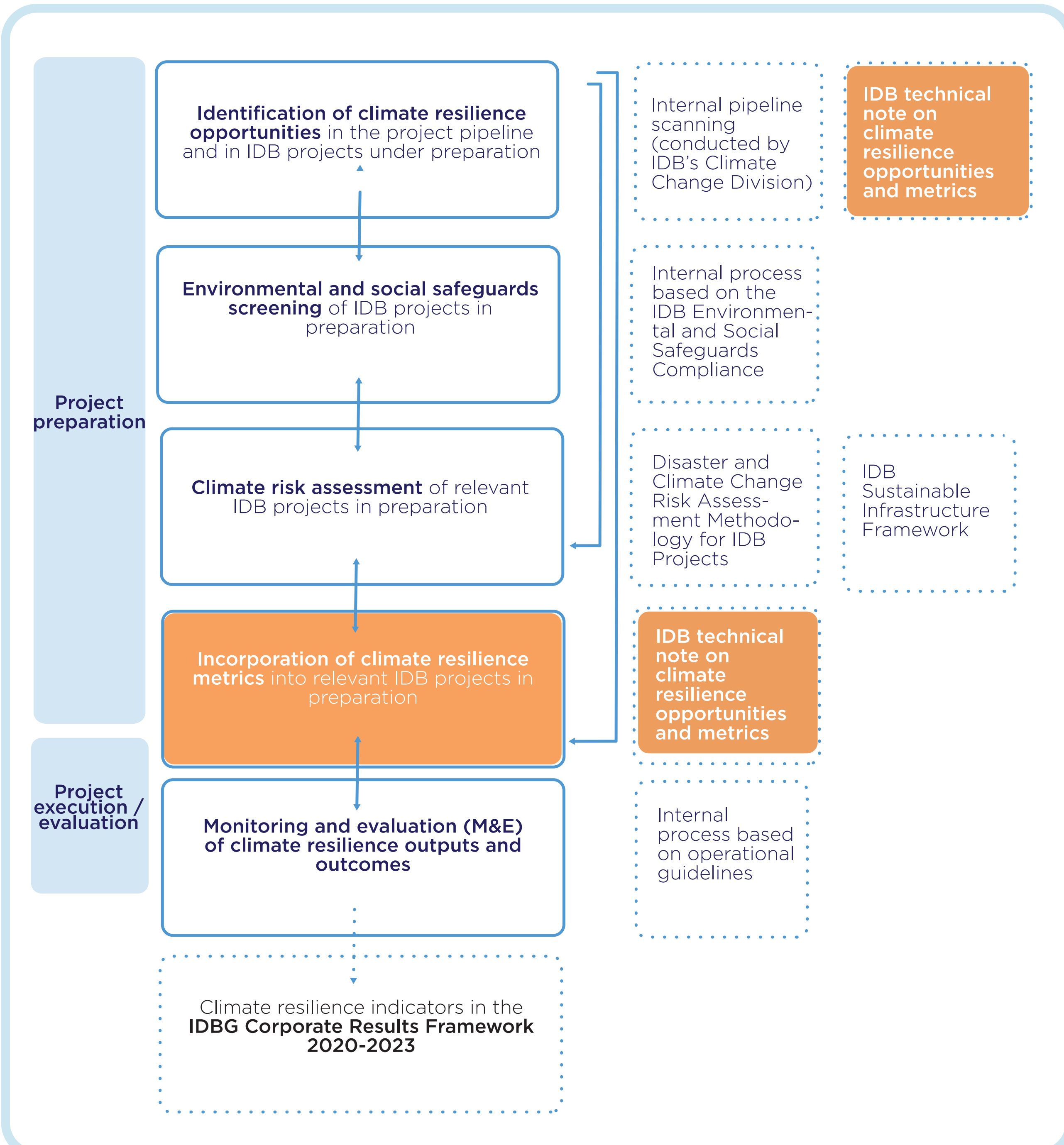
9. While the [IDBG corporate results framework 2020-2023 (CRF)]() includes a group of indicators related to climate resilience,[7] there is no official mandate for IDB projects to include specific indicators on climate resilience-related outputs and/or outcomes across projects. Monitoring actions on adaptation are limited to the adaptation finance tracking of the project and to the disaster and climate-change risk screening process. The only projects in which specific indicators for climate resilience have been consistently included are those which main objective is to build institutional capacity on disaster risk management or financial programs for creating weather-related insurance facilities. However, many other development projects (can) make also important contributions to climate resilience, and a common approach or framework for cli-

[6] For the 2019 report see https://publications.iadb.org/en/2019-joint-report-on-multilateral-development-banks-climate-finance.
[7] Indicators 2.20 "Beneficiaries of enhanced disaster and climate change resilience (#)" and 3.15 "Projects with considerable disaster and climate change risk that applied risk analysis to identify resilience actions (%)."

mate resilience metrics would guide specialists in the development of specific indicators at the project level complementing those of the CRF.

10. Operationalizing climate resilience throughout the approval and implementation cycles of a development project involves different steps: scanning the pipeline to identify opportunities to include climate resilience considerations in relevant projects, conducting a disaster and climate-change risk screening, and developing a monitoring and evaluation plan to be used during the implementation of the project to report achieved results and sustainable development objectives. Figure 1 illustrates different sequential "entry points" or actions to ensure that climate resilience is factored in throughout the project design and implementation phase. At IDB, projects are scanned for climate resilience opportunities, and they are screened for disaster and climate-change risks. What is still needed to close the loop within IDB is guidance in developing climate resilience output and outcome indicators. This document aims to contribute to the process of identifying climate resilience opportunities in the project pipeline and in IDB projects under preparation (box 1 in Figure 1) through a better conceptual understanding of climate resilience as well as contribute to the actual incorporation of climate resilience metrics into relevant IDB projects (box 4 in Figure 1). Along these lines, the climate resilience metrics framework described in this document would also be instrumental in helping sectoral projects contribute towards the climate resilience indicators that have been included in the IDBG Corporate Results Framework.

Figure 1: Illustration of processes to incorporate climate resilience within IDB operations (elements of an operational climate resilience framework)



11. The **scanning of the project pipeline** is an internal process conducted by the IDB Climate Change Division on an annual basis with follow-ups throughout the year. This exercise aims at enhancing climate-change mainstreaming activities for relevant development projects and it is instrumental for (i) increasing the number of projects with embedded activities to increase climate resilience and/or reduce greenhouse gas (GHG) emissions, (ii) enhancing internal mechanisms to track and report climate finance in accordance with the joint MDB Climate Finance Tracking Methodologies,[8] (iii) nurturing dialogue between the IDB and its member countries around climate resilience and increasing demand from the region for climate-resilient projects, (iv) fine-tuning regional/national financing estimates for countries to include climate resilience elements in project design, (v) identifying opportunities to include soft-measures for building adaptive capacity, thus complementing any climate analysis required (e.g., vulnerability/climate impact assessments and disaster risk assessments amongst others), and (vi) creating knowledge on mainstreaming climate risk and climate resilience for further dissemination and training among IDB employees.

12. This initial scanning exercise is not as detailed as the risk-screening process conducted by the Environmental and Social Solutions Unit, but is rather a filtering exercise to identify those projects that offer tangible opportunities to include climate resilience in their components as early as possible. In this way, human and monetary resources of the Climate Change Division are prioritized to those projects with a greater potential and need for climate resilience measures. The scan is conducted as a part of the annual programming exercise led by the Vice Presidency of Countries (VPC) for all internally registered lending and non-lending operations.

13. The definitions and examples of climate resilience elements and capacities presented in this technical note will be an important tool to facilitate the pipeline and project discussions with sector teams that follow the initial scanning exercise. Having a common understanding of how climate resilience can be increased, how losses can be reduced, and how coping ability can be enhanced through different climate resilience elements will make it much easier for sector teams to identify climate resilience opportunities within their sector activities.

14. The **Environmental and Social Safeguards Screening of projects in preparation** stems from the *Disaster risk management policy (OP-704) (IDB 2007)*, which is part of the IDB's environmental and social safeguard system, and which is currently being modernized under the new Environmental and Social Policy Framework (ESPF).[9] The IDB's Environmental and Social Solutions Unit is in charge of conducting the screening for the IDB's portfolio for all projects that require an environmental and social safeguards specialist on the team (all high- and moderate-risk projects (categories A and B)). The screening is conducted as early as possible during project preparation, usually during project identification, and prior to developing the Project Profile (PP).[10] The screening is a first flag-raising mechanism within the disaster and climate-change risk assessment process. It is aimed at quickly identifying possible risks to a project during the very first stage of project preparation, when there is limited information available. It is conducted based on (i) a gross identification of natural hazards that the project may be exposed to and (ii) a gross estimation of the project's own criticality and vulnerability. As a result of the screening, a risk classification (low, moderate, or high) is assigned to the project. This risk classification

[8] See https://publications.iadb.org/en/2019-joint-report-on-multilateral-development-banks-climate-finance.
[9] Currently the IDB is undergoing an update of its environmental and social safeguard policies. The new Environmental and Social Policy Framework (ESPF) was approved by the Board of Executive Directors of the IDB on September 16, 2020, and its implementation is expected to begin in the second semester of 2021. Under the new policy framework, the topic of disaster and climate change risk is maintained, particularly under Standards 1 and 4.
[10] The PP is the document that links the proposed project to the Country Strategy (CS) and the Sector Framework Document(s) (SFD), and lays out the project's technical options and risks.

determines the process requirements from this point on: for high-risk projects a Disaster Risk Assessment (DRA) must be conducted; for moderate-risk projects the project team may evaluate the need for a DRA, and for low-risk projects there is no further action required. The IDB follows the *Disaster and climate change risk assessment methodology* to continue this risk identification and assessment process (the Methodology describes the entire process starting from the screening up to project-specific risk assessments).[11]

15. The ***Disaster and climate change risk assessment methodology* for IDB projects** is rooted in the existing Disaster Risk Management Policy of 2007, the Disaster Risk Management Guidelines from 2008, and the Bahamas Resolution of 2016 [12] (IDB 2016), and has been incorporated into the new IDB ESPF. It builds upon and strengthens the environmental and social safeguards screening process and provides guidance for project teams to conduct disaster and climate-change risk assessments in relevant operations, ensuring added value to projects.

16. The approach included in the Disaster and Climate Change Risk Assessment Methodology has broader applicability but is particularly relevant for projects with infrastructure components. The Methodology explains each step of the disaster and climate-change risk assessment, different types of hazards as well as sector- and structure-specific issues that need to be addressed, and it provides practical support to project teams, executing agencies, technical experts, and external consulting and design firms on how to integrate disaster and climate-change risk considerations into project preparation and implementation, where relevant. The methodology involves five steps, which are grouped into three phases:

1. Phase 1—Screening and classification: all IDB projects are screened and classified based on location and hazards, as well as criticality and vulnerability.

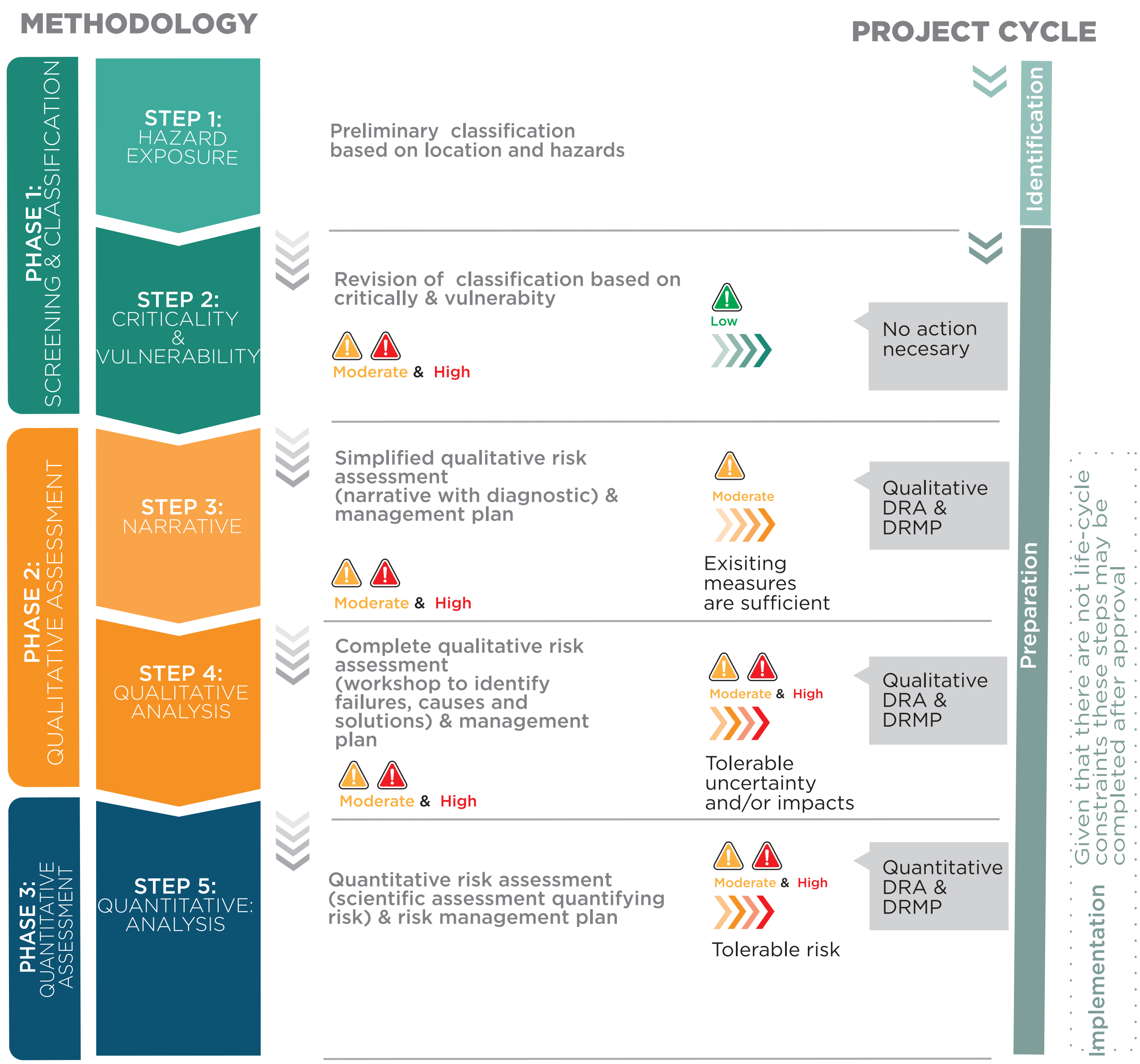
2. Phase 2—Qualitative assessment: a qualitative disaster and climate-change risk assessment is conducted for moderate- or high-risk projects.

3. Phase 3—Quantitative assessment: a quantitative disaster and climate-change risk assessment is conducted for moderate or high-risk projects and it is applied to the specific activities of the project that require quantification as identified in Phase 2.

17. Figure 2 illustrates how the Disaster and Climate Change Risk Assessment Methodology is designed as a sequence of steps with respective minimum requirements. Not all steps have to be completed for all operations; efforts and resources are commensurate with the levels of risk. In an incremental manner with each successive step, the methodology allows for various types of DRAs that vary in complexity and level of detail.

[11] One of the targets of the new IDB Corporate Results Framework is that by 2023, 100% of moderate and high-risk projects will have a disaster risk narrative (step 3 of the Disaster and Climate Change Risk Assessment Methodology).
[12] In the Bahamas Resolution, the governors of the IDBG welcomed the IDBG Management's objective to improve the assessment of climate risks and to identify opportunities for resilience and adaptation measures at the project concept stage, and the IDBG committed to screening relevant projects for climate risks in order to increase investments in resilience, particularly for countries that are most vulnerable to the impacts of climate change.

Figure 2: Phases and steps of the Disaster and Climate Change Risk Assessment Methodology for IDB Projects



Notes: Should the assessment be carried out after board approval, a legal condition might be included in the loan contract for it to be conducted.

18. Once vulnerabilities and risks have been identified and opportunities seized to include climate resilience elements within a development project, it will be important to document relevant activities and measures in key project documents.

19. To effectively **incorporate climate resilience metrics in individual development projects,** the type of climate resilience indicators for each project needs to be appropriate, considering the project's objectives, scope, financing amount, expected lifetime, institutional arrangements, and monitoring and evaluation (M&E) capacities and resources.

20. At the IDB, there are a number of key conceptual and operational documents that can be used as entry points. The project's theory of change serves well as the starting point for climate resilience considerations, followed by the project's results matrix, which illustrates all indicators defined for the project at impact, outcome, and output level. For relevant projects that aim to build climate resilience or that aim to climate-proof project activities, the results matrix should include climate resilience outcome indicators, and related output indicators that illustrate how climate resilience will be incorporated into the project's components and activities. The identification of these indicators will be facilitated by the framework presented in this technical note. The monitoring plan of the project will then include additional information on how specific indicators should be measured, monitored, and interpreted, and ideally, how lessons can be captured to inform future projects. These details are very important and will help enhance the learning processes of mainstreaming climate resilience into operations.

21. The **M&E of climate resilience outputs and outcomes** should be incorporated into regular already existing processes for monitoring project results. For example, relevant climate resilience outputs and outcomes should be included in the results matrix of the project and corresponding M&E Plan. Once in execution, monitoring tools such as the Project Monitoring and Reporting (PMR) platform, are key for following the advancement of the climate resilience-related activities that are financed by the project and have been documented in the project results matrix. In addition, other documents such as the Operational Manual can be used to include relevant implementation-related information on climate resilience, to guide procurement processes. In some cases, the development of an evaluation plan and/or an impact assessment may be of great value in attributing the effectiveness of the implemented climate resilience activities against climate-related risks. This can of course be challenging due to the uncertainty, long-time horizons, and shifting baselines associated with climate change (e.g., when intending to evaluate the performance of infrastructure designed to withhold a certain type, frequency, and amplitude of extreme event). It is also important to mention that at the Project Completion Report (PCR) stage, project outcomes will be measured again for the last time during the execution life of an operation, and an analysis of their effectiveness, relevance, contribution, and attribution will be made. In addition, lessons learned will be summarized and reported, to be used in future operations. This is key for adaptation to climate change, which, in many cases, is a "learning by doing" process.

22. Two important aspects that need to be factored in when defining metrics for climate resilience in the context of M&E are data availability and quality. If the data for building an indicator for climate resilience is not available and the project is supposed to generate them, clear procedures for data collection, interpretation, storage, and analysis need to be put in place. When doing this, it is important to evaluate the level of maturity of the data collection systems at hand at country/ municipality/system level, as well as the costs and benefits of data generation and collection.

23. Figure 3 summarizes eight of the most relevant approaches for evaluating climate resilience indicators. SMART criteria (Specific, Measurable, Achievable, Relevant and Time-bound) are required for IDB project indicators and also apply for climate resilience indicators. Climate resilience output and outcome indicators need to be SMART.

Figure 3: Criteria for evaluating climate change-related indicators

UNFCCC (2010)
- relevant
- measurable
- specific
- achievable
- time-bound (SMART)

Kadir et al. (2013)
- representativeness
- data quality
- sensitivity
- decision support

Natural England (2010)
- relevance (progress towards objective)
- measurability
- consistency/continuity
- easily understood

Carmen et al. (2003)
- data already collected reliably
- long-term data available
- sensitivity to climate
- easily understood
- already part of suite of indicators

EEA (2012)
- relevance
- data quality and accessibility
- sensitivity to climate
- easily understood and accepted
- robustness/known uncertainty
- coverage

CCME (2003)
- measuring important changes
- reliable long-term data
- clear and direct sensitivity to climate
- coverage/data available for most parts of country

Erhard et al. (2003)
- relevance for policy makers
- coverage/spatial representation
- easily understood/ transparent
- analytical soundness and measurability
- potential inclusion in integrated assessment

Schönthaler et al. (2011)
- relevance (particularly cause-effect relationships)
- scientific validity
- data availability
- connection with other indicator systems
- ease of reporting at local level

Source: All sources in this table are cited in Ellis 2004.

24. The MDB-IDFC technical paper *A framework and principles for climate resilience metrics in financing operations* (African Development Bank et al. 2019) lists the following four core concepts that apply to the development of climate resilience metrics:

1) a context-specific approach to climate resilience metrics,

2) compatibility with the variable and often long timescales associated with climate-change impacts and building climate resilience,

3) an explicit understanding of the inherent uncertainties associated with future climate conditions, and

4) the ability to cope with the challenges associated with determining the boundaries of climate resilience projects.

25. Functional characteristics of climate resilience metrics presented in the MDB-IDFC technical paper include, amongst others, the applicability of metrics to different life-cycle stages of the project, possibly over a long lifespan; the need for continuous improvement and advanced features of climate resilience metrics; and a consideration of multiple interacting project- or system-level elements.

3.

Defining climate resilience

26. Today's definitions of climate resilience (see Table 1 below) have their origins in ecological literature such as Holling (1973), who defined **stability** as *"the ability of a system to return to an equilibrium state after a temporary disturbance"* and **resilience** as *"a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables."*

Table 1: Resilience definitions

Source	Resilience definitions and characteristics
UNISDR Sendai Framework (2015)	"The ability of a system, community or society exposed to hazards to **resist, absorb, accommodate** to and **recover** from the effects of a hazard in a timely and efficient manner, including through the **preservation** and **restoration** of its essential basic structures and functions."
IPCC (2014)	"The capacity of a social-ecological system to **cope** with a hazardous event or disturbance, **responding** or **reorganizing** in ways that **maintain** its essential function, identity, and structure, while also maintaining the capacity for **adaptation, learning,** and **transformation"**—going beyond ecologists' concerns for the ability of an ecological system to persist to the ability of a human-based systems to transform into something better
OECD (2014)	"The ability of households, communities and nations to **absorb** and **recover** from shocks, whilst positively **adapting** and **transforming** its structures and means for living in the face of long-term stresses, change and uncertainty."
Constas et al. (2014)	"The capacity that ensures that adverse stressors and shocks do not have long-lasting adverse development consequences"—requiring a definition for "long-lasting adverse development consequence" and highlighting the fact that there is a distribution of potential development outcomes associated with a distribution of shocks, so that increasing resilience means shifting the distribution of outcomes

27. A meta-analysis across various definitions of resilience (ODI 2016) highlighted that (1) resilience should enable systems to function and even flourish in the face of shocks and stresses, (2) most definitions include components of limiting damage from disturbances and recovering from shocks, and (3) managing change is key, but only some definitions incorporate transformative shifts.

28. Given the above, we find it most useful to define climate resilience as ***"The ability of households, communities, and systems to anticipate, absorb, and recover from weather shocks and slow-moving changes, and to positively adapt and transform in the face of long-term stresses, change, and uncertainty induced by climate change."*** [13]

[13] With this definition, and since most of the literature considers vulnerability to be a function of hazards, potential losses, and the ability to recover, we consider vulnerability the opposite of resilience. For the debate about whether vulnerability and resilience are two sides of the same coin see, e.g., Adger (2006), Miller et al. (2010), and Constas et al. (2014b).

Box 1: Resilience at a systems level

Most authors define resilience at a systems level, going back to the ecological definition that refers to the functioning of a system as a whole. In the context of a development operation, it is important to understand how and where project activities and inputs fit into systems that influence the extent to which the project can deliver outputs, outcomes, and impacts. In most cases, this will include the disaster risk management system, the market system, the public service delivery system, and the ecological system. Projects may also find it more useful to focus on more specific systems within these broader systems, e.g. the social safety net system, specific input and output market systems, the food system, the water or electricity supply system, or a specific watershed or forestry system.

3.1 Climate resilience capacities

29. With our definition of climate resilience at hand, we review climate resilience capacities and elements from various conceptual frameworks to arrive at climate resilience measures and metrics that could be included in projects.

30. As illustrated in Table 1 above, the various definitions of resilience highlight different capacities: absorb, accommodate, adapt, anticipate, resist, cope, improve, learn, maintain, preserve, recover, reorganize, respond, restore, transform. Another way to look at this is that all these capacities help capture different dimensions of resilience, which will be broken down in this section.

31. The World Bank resilience framework (World Bank 2017), for instance, organizes resilience-building activities around absorptive, adaptive, and transformative capacities:

1. **Absorptive capacity:** mitigating negative impacts of current weather hazards.
2. **Adaptive capacity:** moderating potential future climate impacts.
3. **Transformative capacity:** the ability to create a fundamentally new system to avoid negative impacts of climate change.

32. In contrast to the resilience framework of the World Bank, Béné et al. (2012) formulate resilience capacities as responses at increasing scales of the challenge:

1. **Absorptive capacity:** a set of capacities that allows systems to remain stable in the face of shocks.
2. **Adaptive capacity:** incremental adjustments that systems can make when absorptive capacity is exceeded.
3. **Transformative capacity:** systemic change that happens when adaptive capacity is exceeded.

33. Constas et al. (2014a and 2014b) suggest that resilience is best understood as an ex-ante capacity that helps to reduce the likelihood that shocks will have lasting adverse development consequences. Actions taken now to increase this capacity will thus increase the ability to recover from shocks or stressors after they have occurred and will reduce damages that occur for any given weather event. The authors also highlight the three resilience capacities, absorptive, adaptive, and transformative, following the World Bank Resilience Framework (2017) and Béné et al. (2012) as well as the OECD Guidelines (2014) for resilience systems analysis, amongst many others.

34. The EU-CIRCLE[14] resilience framework (2016) defines five capacities: anticipatory, absorptive, coping, restorative, and adaptive. The definitions used here of anticipatory capacity (ability to reduce impacts through preparedness and planning) and absorptive capacity (ability to buffer/absorb the impacts of climate extremes in the short-term) are usually combined by other authors into absorptive capacity. Both coping capacity (ability to manage adverse consequences of climate extremes) and restorative capacity (ability of the system to be repaired easily and efficiently[15]) refer to actions taken after a specific weather shock has occurred. Finally, adaptive capacity (the ability to make changes to adapt to long-term challenges posed by climate change) is closer to other definitions of transformative capacity in the EU-CIRCLE framework.

35. UNISDR (2016) also suggests elements of resilience associated with various capacities but does not sub-categorize each element exclusively under one specific capacity. Overall, the UNISDR definitions have substantial overlap with the World Bank definition of resilience capacities, but do not go as far into a description of the elements of resilience due to the focus on DRM. UNISDR does stress the need to "build back better" to avoid future damages; this might mean infrastructure designed to be more robust can also include designing infrastructure so that it can be repaired more easily or can be retrofitted in the future as climate-change impacts become better known, or can be sited differently.

36. Having reviewed the existing definitions of the different capacities connected with climate resilience, we believe that it is most useful to distinguish the capacity to take actions *ex ante* to reduce losses that result from extreme weather events or uncertain future climate changes from the capacity to recover from adverse events after they have happened, that is *ex post*. Thus, the terminology we will use for these capacities is **absorptive capacity and restorative capacity, both of which can have a transformative dimension**.

37. With our label for the second capacity, "restorative capacity," we deviate from the more commonly used term of "adaptive capacity." Restorative capacity has been more often used in the critical infrastructure literature, but we believe it better captures what has often been included in different definitions of adaptive capacity. Our definition of restorative capacity includes both coping capacity[16] (the ability of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters (EU-CIRCLE 2016)) and restorative capacity in the EU-CIRCLE resilience framework (associated with recovery, the ability of a system to be repaired easily and efficiently (EU-CIRCLE 2016)). Finally, transformative capacity, the ability to create a fundamentally new system as referenced in the World Bank resilience framework (2017), can be related to both absorptive capacity and restorative capacity.

[14] Critical Infrastructure Resilience Platform.
[15] The "ability of a system to be easily repaired" is an important element often missing from other resilience frameworks.
[16] For instance: EU-CIRCLE (2016) and Biringer et al. (2013).

Table 2: Climate resilience capacities that shall guide the identification of climate resilience opportunities in IDB projects

Climate Resilience Capacity	Definition
Absorptive	The capacity to reduce losses resulting from extreme weather events and/or slow-moving changes by taking actions *ex ante*.[17]
Restorative	The capacity to recover from losses and damages that result from extreme weather events and/or slow-moving changes by taking actions ex post, including "building back better".
Transformative (*absorptive- or restorative-related*)	The capacity to create a fundamentally new system through a systemic shift.[18] Complementary definitions include the degree to which a system can build the capacity to learn and adapt (Carpenter et al., 2001; Walker et al., 2002; Folke 2006).

38. Focusing on (transformative) absorptive and restorative capacities will help project teams to ***design project measures that address specific elements that enhance these climate resilience capacities.*** This, in return, will contribute to decreased losses due to future climate changes or weather events and/or an increased ability to cope *ex post* across IDB projects and amongst partner communities, institutions, and clients.

3.2 Climate resilience elements

39. Climate resilience elements or attributes are an important tool for operationalizing climate resilience and designing projects that are climate-resilient and/or build climate resilience. Considering climate resilience elements in project preparation is critical in order to take advantage of climate resilience opportunities, even—and sometimes more importantly—within sectors and projects where the connection to climate resilience may not be obvious.

40. Climate resilience elements help to characterize project activities that are aimed at increasing absorptive- and restorative-resilience capacities at the output level. These elements thus provide a basis for developing output-level climate resilience indicators. (At the outcome level, the results of the enhanced absorptive- and restorative-resilience capacities will be measured by indicators that describe reduced losses or increased coping ability.)

41. While we present a number of resilience elements and sub-elements that have been identified in both socioeconomic-based resilience frameworks as well as in the more ecosystem-centric work and respective examples in this section, an individual project will mostly focus on a small number of climate resilience elements. This is also recommended to facilitate the integration of climate resilience elements into the project design, to ensure a full articulation between the selected elements and the project scope, and to ensure that progress can be tracked throughout the project life cycle (see World Bank 2020a).

42. Table 3 presents definitions of the resilience elements of ***protection, robustness, preparedness, recovery, diversification, redundancy, integration/connectedness, and flexibility*** and the related sub-elements ***modularity, managing slow variables and feedback, learning/awareness, reparability, reconstruction, building back better, polcentric governance systems, complex adaptive systems thinking, and options.***

[17]This follows the definition of anticipatory capacity provided by Constas et al. (2014b) and OECD (2014). It is narrower than Béné et al. (2012), since we separate the ability to recover. Our definition also includes both anticipatory and absorptive capacity definitions used by EU-CIRCLE (2016).
[18]According to Lonsdale et al. (2015), there is no clear consensus on what a transformative activity could be for adaptation. However, some authors highlight, for example, that investing in nature-based solutions and developing policy and regulations for climate resilience (Hill 2013) could be considered transformative actions.

Table 3: Resilience elements and definitions

Resilience element	Definition
Protection	Extent to which the community, infrastructure, and/or system is protected against damage or harm from climate-related shocks or stresses.
Robustness	Ability to withstand the impacts of shocks and fluctuations and to maintain its characteristics, performance, and functions in the face of a crisis[19]
Preparedness	Ability of the community and/or system to manage and cope with climate-related shocks or stresses Preparedness includes the following sub-elements: ***Modularity,*** the degree to which a system's components may be separated and recombined, facilitating recovery after a climate shock and ability to adapt to future climatic changes ***Managing slow variables*** and feedback, the ability to identify key slow-changing climatic variables (e.g., temperatures) and responses (termed "feedback" in the eco-systems literature) that help to identify critical thresholds, maintain system functioning as well as to offset the negative impacts of these changes[20] ***Learning/awareness,*** the ability to generate feedback, gain or create knowledge, and build the skills, attitudes, and competencies needed to innovate and adapt to change[21]
Recovery	Ability to recover from climate-related shocks and emergencies Recovery includes the following sub-elements: ***Reparability,*** ability to repair something that was damaged ***Reconstruction,*** ability to rebuilt something that was damaged or destroyed ***Building Back Better,*** extent to which risks of future climate-related shocks and disasters are reduced through the integration of risk reduction measures into the restoration of physical infrastructure, systems, and other mechanisms
Diversification	Extent to which assets or activities are distributed, allocated or varied in a way that reduces exposure to risks and balances losses under different adverse scenarios
Redundancy	Availability of additional/spare/backup resources or capacity that can be accessed in the case of shocks or in the event of disruptions and that help withstand failure and ensure continuity of services[22]
Integration/ Connectedness	Degree to which climate resilience is integrated across the system/ Breadth of resources and structures that can be accessed, at multiple levels, in order to respond or adapt to shocks or stressors[23] Integration/Connectedness includes the following sub-elements: ***Polycentric governance systems***, extent to which multiple governing bodies interact in a governance system to make and enforce rules ***Complex adaptive systems thinking***, extent to which the complex inter-actions and dynamics between actors and systems are considered
Flexibility	Ability to respond to uncertainty associated with climate change and disaster risk, to address challenges, and to utilize the opportunities that may arise from change[24] Flexibility includes ***Options***, the ability to choose between different alternatives

43. Table 4 takes a closer look at the presented resilience elements for the sector of agriculture and natural resources.

[19] EU-CIRCLE (2016) and World Bank (2020a). / [20]GRAID (2020). / [21]World Bank (2020a) and World Bank (2020b). /[22]EU-CIRCLE (2016), World Bank (2020a), and World Bank (2020b). / [23]World Bank (2020a) and World Bank (2020b). /[24]World Bank (2020a) and World Bank (2020b).

Table 4: Illustration of resilience elements in the sectors of agriculture and natural resources management and water/energy

Relevant element	What does this mean in this sector?	For example?
Protection	**Agriculture/natural resources:** Rural communities, infrastructure, and/or natural resources systems are preserved from damage or harm from climate-related shocks or stresses **Water/energy:** Green and gray infrastructure[25] essential for the provision of services to the population are preserved against climate shocks (e.g., 200-year storm). Protected and well-managed infrastructure and ecosystem services contribute to local communities' climate resilience	**Agriculture/natural resources:** Drainage system to protect rural roads or crops, irrigation systems that protect crops during droughts, or measures to protect coastal infrastructure and communities (such as the restoration of wetlands, mangroves, and marshes or the upgrading of sea walls) or urban neighborhoods (such as the restoration of lagoons and wetlands to provide a buffer area between urban neighborhoods and rivers during peak flood events) **Water/energy:** Points within an electricity/potable water network that are vulnerable to extreme events are identified and redesigned/overhauled to improve the system's overall level of protection against climatic hazards; nature-based solutions (NBS[26]) for capturing, retaining, and infiltrating water at the basin level are restored and well managed; pairing upgrades to build hydropower infrastructure with investments in watershed management to protect the facility's water supply (e.g., supporting the creation of community tree nurseries to serve as sources for reforestation and encouraging the production of non-conventional crops in the watershed).
Robustness	**Agriculture and natural resources:** Rural communities, infrastructure, and/or natural resources systems are able to withstand the impacts of shocks and fluctuations and to maintain their characteristics, performance, and functions in the face of a crisis **Water/energy:** Electricity and potable water supply systems are robust if they have the ability to maintain functionality to meet customers' demands when they are exposed to a climatic shock (e.g., 200-year storm, extreme heat, or wind)	**Agriculture and natural resources:** Climate-resilient rural infrastructure, mechanisms to promote adoption of resilient agricultural technologies, climate-resilient crop systems (e.g., agroforestry, irrigation, weather-resistant crop varieties) **Water/energy:** Infrastructure and ancillary equipment of a water supply/electricity system are designed and built to withstand a 200-year storm and winds of more than 200 km per hour and are able to maintain the level of service for which they were designed
Preparedness	**Agriculture and natural resources:** The rural community, natural resources, are able to manage and cope with climate-related shocks or stresses **Water/energy:** Electricity and water supply systems have in place a set of precautionary and specific measures that guarantee the reliability of provided services in the face of a climate-related shock. These measures include physical preparations and training/plans for emergency action **Modularity:** **Agriculture and natural resources:** The components of rural, infrastructure, equipment, or technologies can be separated and recombined and thus facilitate recovery after a climate shock and adaptation to future climatic changes **Water/energy:** Electricity and water supply systems with high modularity are able to buffer or restrain a climate shock to one of their components, avoiding its spread to the global network **Managing slow variables and feedback:** **Agriculture and natural resources:** Key slow-changing climatic variables (e.g., temperatures) and responses ("feedback") that affect agricultural productivity and the functioning of natural resources systems can be identified, which helps to identify critical thresholds, maintain system functioning, and offset the negative impacts of these changes **Water/energy:** Changes in average and extreme temperatures affect performance of certain electrical components such as transformers, likewise, higher temperatures mean higher evapotranspiration rates and an increase in the consumption of water. These effects need to be managed so that the system is able to keep performing at the desired standard. **Learning/Awareness:** **Agriculture and natural resources:** Rural communities and/or relevant sector institutions are able to generate feedback, gain or create knowledge, and build the skills, attitudes, and competencies needed to innovate and adapt to change **Water/energy:** Learning mechanisms at the operations level for potable water and electricity systems with the potential to trigger "transformative" changes in the operation of the infrastructure (whether to better prepare for climatic shocks or to respond to them)	**Agriculture and natural resources:** Accurate and timely weather information disseminated in accessible formats and readily understood by farmers and water plants' and electricity systems' operators, social emergency response plans, equipment to repair damaged agricultural infrastructure, DRM response plans **Water/energy:** Gray and green flood management measures including contingency plans and infrastructure, such as control dikes, concrete drainage networks, flooding basins, and parks on urban river margins **Modularity:** **Agriculture and natural resources:** Rural infrastructure (irrigation, drainage, combination of seawalls and mangroves) built with modular components for quicker and less costly repairs, and maintained with local participation **Water/energy:** Electricity and potable water systems designed and built with high connectivity so that they are able to isolate a group of nodes that have failed when exposed by a climatic shock, maintaining network functionality. Upgrades/improvement to a potable water or electricity network that promote modularity contribute to increasing the resilience of the system to climate-related shocks **Managing slow variables and feedback:** **Agriculture and natural resources:** Continuously updated crop models that incorporate impacts of weather events on range of crops **Water/energy:** Certain sub-station components in electrical systems use materials that can withstand higher temperatures; electricity infrastructure is located outside flood-risk areas; potable water and electricity infrastructure located near coastal areas, factor in sea-level rise projections in the design. **Learning/Awareness:** **Agriculture and natural resources:** Extension system staff has skills and resources to evaluate resilience of alternative agricultural practices, data collection and analysis related to climate-related changes in productivity, functioning of natural resources systems, climate-resilient crop varieties, etc. **Water/energy:** Online training, courses, and practical pilot studies on the development of integrated watershed management plans that specifically look at identifying priority areas for reforestation and other green infrastructure interventions in the upper river basin to strategically prevent flooding and improve water quality

[25]Green infrastructure: a subset of nature-based solutions (NBS) that intentionally and strategically preserves, enhances, or restores elements of a natural system to help produce higher-quality, more resilient, and lower-cost infrastructure services (see also WWAP/UN-Water 2018).
Green-gray infrastructure: a combination of traditional gray infrastructure investments with ecosystem management to produce more resilient and lower-cost services.
[26]Defined as the strategic restoration, protection, or management of ecosystems to intentionally achieve development outcomes (Cohen-Shacham et al. 2016).

Table 4 (continued): Illustration of resilience elements in the sectors of agriculture and natural resources management and water/energy

Relevant element	What does this mean in this sector?	For example?
Recovery	**Agriculture and natural resources:** Rural communities, natural resources systems and potable water/electricity systems are able to recover from climate-related shocks and emergencies **Water/energy:** Electricity and water supply systems are able to return to a normal operation mode after failure caused by a climatic shock and to regain control of key processes that allow the system to provide a reliable and continuous quality service **Reparability:** **Agriculture and natural resources:** Rural communities and/or relevant municipal/sector institutions are able to repair damaged rural infrastructure or ecosystems **Water/energy:** Electricity and potable water systems can be restored efficiently to standard service status after damages caused by a climate shock **Reconstruction:** **Agriculture and natural resources:** Rural communities and/or relevant municipal/sector institutions are able to rebuild rural infrastructure or ecosystems that were damaged or destroyed **Water/energy:** Electricity/potable water infrastructure can be rebuilt in a timely manner to regular operation standards after failure/partial failure caused by a climate shock **Building Back Better:** **Agriculture and natural resources:** Risks of future climate-related shocks and disasters are reduced through the integration of risk reduction measures into the restoration of rural infrastructure, natural resources systems, and sector mechanisms **Water/energy:** Electricity/potable water networks, damaged/destroyed infrastructure rebuilt, taking into consideration identified systems' vulnerabilities/weakest points to climate-related shocks	**Agriculture and natural resources:** Social safety nets aimed at the rural population or specific groups, such as farmers, that are responsive to weather shocks. Contingency plans for infrastructure and operations could make a difference on how efficiently and effectively a system can recover from a climate shock **Water/energy:** Contingency plans and preventive maintenance routines developed and in place to speed up the system's recovery after being damaged by a climatic shock **Reparability:** **Agriculture and natural resources:** Adoption of building laws requiring irrigation or drainage infrastructure designs that can be more easily repaired, rural infrastructure built to be easily repaired, enhanced capacities in rural communities to repair damaged infrastructure, equipment to make repairs, tree support structures **Water/energy:** Adoption of design standards or maintenance practices for electricity/potable water networks that enable an efficient and effective restoration of services after a system failure/partial failure due to a climate shock **Reconstruction:** **Agriculture and natural resources:** Rural communities re-built, forests reforested, timely weather-responsive public works to facilitate reconstruction **Water/energy:** Electricity/potable water networks that count on a reconstruction plan/strategy to restore gray and green infrastructure standard service levels after failure/partial failure caused by a climate shock **Building Back Better:** **Agriculture and natural resources:** Agriculture storage and market-related infrastructure reconstructed to higher standards, coastal infrastructure reconstructed to higher resilience standards and land use changes promoted as transformative action **Water/energy:** Electricity distribution network destroyed by a hurricane is redesigned using a different configuration and lay-out with inputs from existing system's vulnerability assessments and projected climate-change impacts.
Diversification	**Agriculture and natural resources:** Agricultural or natural resources assets or activities are distributed, allocated or varied in a way that reduces exposure to risks and balances losses in different adverse scenarios **Water/energy:** Electricity or water supply systems have access to a variety of reliable and independent sources, facilitating the management of existing or expected climate-related risks	**Agriculture and natural resources:** Adoption of a productive system that is diversified, having a variety of different crops, e.g., agroforestry, coastal inhabitants that have inland jobs as well as jobs in fishing, or that have diverse equipment to fish a variety of species **Water/energy:** Master plans for water supply infrastructure to assess various water resources and their associated climate risks in a specific timeframe and to recommend a combination of different sources (superficial and subterranean) to achieve water security (in terms of service reliability and quality)
Redundancy	**Agriculture and natural resources:** Additional/spare/back-up resources or capacity available that can be accessed in the case of shocks or in the event of disruptions and that help withstand failure and ensure continuity of agricultural activities or natural resources systems' management **Water/energy:** Electricity and/or water supply systems include in their design additional components which are not strictly necessary to functioning, in case of failure in other system components due to a climatic shock, to provide a continuous **and reliable service provision**	**Agriculture and natural resources:** Back-up equipment, e.g., spare parts for the irrigation system, back-up feed sources for livestock during drought, variety of crops that produce at different times of the year and respond differently to climate shocks **Water/energy:** Electricity network designs include provisions for alternative paths of operation by means of (i) standby redundancy such as generator/battery, (ii) active or parallel redundancy, for example by splitting the load among a number of units, each capable of carrying the total load

Table 4 (continued): Illustration of resilience elements in the sectors of agriculture and natural resources management and water/energy

Relevant element	What does this mean in this sector?	For example?
Integration/ Connectedness	**Agriculture and natural resources:** Climate resilience is integrated across the system, various resources and structures can be accessed, at multiple levels, to respond or adapt to shocks or stressors **Water/energy:** Elements of an electricity supply network/water supply system are linked to each other, allowing the system to operate efficiently as one entity. A dense system is said to be well interconnected **Polycentric governance systems:** **Agriculture and natural resources:** Multiple governing bodies relevant for the sectors of agriculture and natural resources interact to make and enforce rules **Water/energy:** Multiple governing bodies that are relevant for the sustainable use of water and energy sources interact to make and enforce rules to achieve a collective response when exposed to a climatic shock **Complex adaptive systems thinking:** **Agriculture and natural resources:** The complex interactions and dynamics between relevant actors and systems in the sectors of agriculture and natural resources are considered **Water/energy:** Electricity and/or water systems may be designed and managed as complex adaptive systems given they are[27](i) open systems that comprise many interconnected elements, (ii) non-linear and dominated by feedback loops, and (iii) include coupling patterns among elements	**Agriculture and natural resources:** Agricultural/rural networks that increase access to resources available after weather shock, all relevant stakeholders in rural communities or coastal zones share integrated response plans **Water/energy:** A dense water supply system for a large city provides a reliable, quality service to more than five different areas of the city by efficiently distributing water in times of scarcity among users in the city **Polycentric governance systems:** **Agriculture and natural resources:** Mechanisms for rural community members' participation in DRM planning, efficient multi-sectoral response to weather shocks that affect rural communities **Water/energy:** Water resource management schemes that contribute to adaptation to climate change by seeing the resource as "a common-pool resource," best managed under "common property regimes" **Complex adaptive systems thinking:** **Agriculture and natural resources:** DRM, health, education agencies, and farmer representatives participating in rural sector working groups **Water/energy:** Interactions between rain and wind seasonality are taken into consideration when planning the expansion or operational improvements of an electricity network; methodologies for the development of IWRP incorporate an approach to complex adaptive systems, under which the basin is seen as a system with specific social, environmental, ecological, and economic characteristics with non-linear interactions and on different temporal and spatial scales
Flexibility	**Agriculture and natural resources:** Rural communities are able to respond to uncertainty associated with climate change and disaster risk, to address challenges, and to utilize the opportunities that may arise from change **Water/energy:** Electricity and/or water supply networks can modify their operational conditions to accommodate changes necessary to maintain system reliability in the face of an external climatic shock **Options:** **Agriculture and natural resources**: Rural/coastal communities can choose between different alternatives **Water/energy**: Electricity/power and water supply systems receive respective water and energy inputs from various independent sources	**Agriculture and natural resources:** Availability of drought resistant seed varieties, availability of short-maturing seed varieties for delayed onset of rain, dense social networks offering informal insurance for rural households **Water/energy:** Electricity network/power systems designed in a way that allows for the high penetration of renewable sources that can be alternated depending on seasonal availability, without compromising the system's stability and performance **Options:** **Agriculture and natural resources:** Crop insurance, flood and surge insurance, weather-responsive public works using local labor **Water/energy:** The electricity network/power system in a country is fed by a diverse group of renewable energy sources that are alternated during the year according to availability to maintain system reliability

[27] Jagustovic et al. (2019).

44. Resilience elements are grouped under certain resilience capacities in some frameworks, sometimes grouping each element exclusively to one capacity (e.g., World Bank 2017), sometimes suggesting different elements associated with certain capacities non-exclusively (e.g., UNISDR 2016).

45. Many of the elements could be cast as either absorptive or restorative capacity, such as preparedness, diversification, or flexibility, whereas others are more exclusively connected with either absorptive capacity (e.g., protection and robustness) or restorative capacity (e.g., recovery and redundancy) as illustrated in **Table 5.**

Table 5: Climate resilience elements and capacities

Element	Absorptive	Restorative	Transformative (absorptive- and restorative-related)
Protection	Restored wetlands, mangroves, and marshes or upgraded sea walls	*Protection is more exclusively connected with absorptive capacity*	System-wide "room for rivers" approach, as promoted in the flood-prone Netherlands
Robustness	Water supply infrastructure designed and built to withstand 200-year storm and winds of more than 200 km per hour, and able to maintain service provision	*Robustness is more exclusively connected with absorptive capacity*	Mechanisms to promote system-wide adoption of resilient technologies or productive practices, e.g., to withstand specific climatic events
Preparedness	Local emergency response plans Transport infrastructure built with modular components to maintain service provision during strong precipitation events ***(Modularity)*** Crop models that are continuously updated and incorporate impacts of weather events on the range of crops ***(Managing slow variables and feedback)*** Data is collected and analyzed on climate-resilient crop varieties ***(Learning/ Awareness)***	Equipment to repair damaged infrastructure Irrigation systems built with modular components for quicker and less costly repairs ***(Modularity)*** Water supply system data outputs that allow identification of damage in the network after climate events and improve targeting reconstruction and repair activities ***(Managing slow variables and feedback)*** Data is collected and disseminated on safe evacuation routes during past flood events ***(Learning/Awareness)***	Integrated system-wide DRM response plans Coastal protection infrastructure built with modular components and a mix of gray and green solutions system-wide ***(Modularity)*** Mechanism established to continually collect and update climate information to determine retrofittingneeds for public utility companies system-wide, e.g., of the drainage system ***(Managing slow variables and feedback)***
Recovery	Recovery is more exclusively connected with restorative capacity	Social safety nets responsive to weather shocks Homes re-built ***(Reconstruction)*** Agriculture storage infrastructure reconstructed to higher standards ***(Building Back Better)***	Adoption of building laws requiring infrastructure designs system-wide that can be more easily repaired ***(Reparability)*** Water supply systems that are built with non-revenue-water equipment and that count on water conservation and management plans ***(Building Back Better)***
Diversification	Diversified labor sources *ex ante*, e.g., inland and offshore jobs that provide income during different times/seasons	Increased ability to re-allocate labor *ex post*, e.g., paid work in reconstruction after storm	Establishment of national formation program to extend skill sets to sectors that are not climate sensitive
Redundancy	*Redundancy is more exclusively connected with restorative capacity*	Back-up generators	Development of facility regulations that require the installation of back-up generators system-wide
Integration/ Connectedness	Mechanisms for community members participation in DRM planning ***(Polycentric governance systems)*** Multi-sectoral and disciplinary models generating options for households ***(Complex adaptive systems thinking)***	Networks that increase access to resources available after weather shock Efficient multi-sectoral response to weather shocks ***(Complex adaptive systems thinking)***	All relevant stakeholders in watershed system, coastal zones, and/or cities share integrated response plans Hierarchical, integrated multi-sectoral response to weather shocks ***(Polycentric governance systems)*** Multi-sectoral and disciplinary models guiding systems-level planning and response ***(Complex adaptive systems thinking)***
Flexibility	Availability of drought resistant or short-maturing seed varieties	Dense social networks offering informal insurance Crop insurance ***(Options)***	Sovereign weather insurance ***(Options)***

4.

Incorporating meaningful climate resilience elements and metrics into a project

4.1 Understanding the theory of change

46. To develop a logical, coherent theory of change and establish a clear causal pathway from climate resilience-related inputs to outputs to outcomes to impacts, the following understanding is useful.

47. We look at expected climate resilience as a function of the ability to cope minus expected losses over a relevant time period. Expected losses[28] are a function of the probability distribution of hazards multiplied by losses that are realized for each specific hazard. Losses are a function of absorptive and absorptive-related transformative capacity as well as other factors affecting the effectiveness of absorptive capacities in reducing losses. Similarly, the ability to cope is a function of restorative and restorative-related transformative capacity as well as other factors that determine how effectively increases in restorative and transformative capacity increase the ability to recover. The resilience capacities are functions of the respective resilience elements. Thus, as described earlier, resilience elements characterize climate resilience outputs.

48. In other words, we see expected climate resilience *ER* as the ability to C cope when shocks occur, minus the product of the hazard probability distribution, H , and potential losses, L , for each potential hazard. We refer to $H * L$ as expected losses.

Equation 1:

$$ER = C\,(Restorative, Transformative; Z_R) - H{*}L\,(Absorptive, Transformative; Z_L)$$

49. Equation 1 above omits the time period in which we are interested, and thus implicitly assumes that expected resilience is

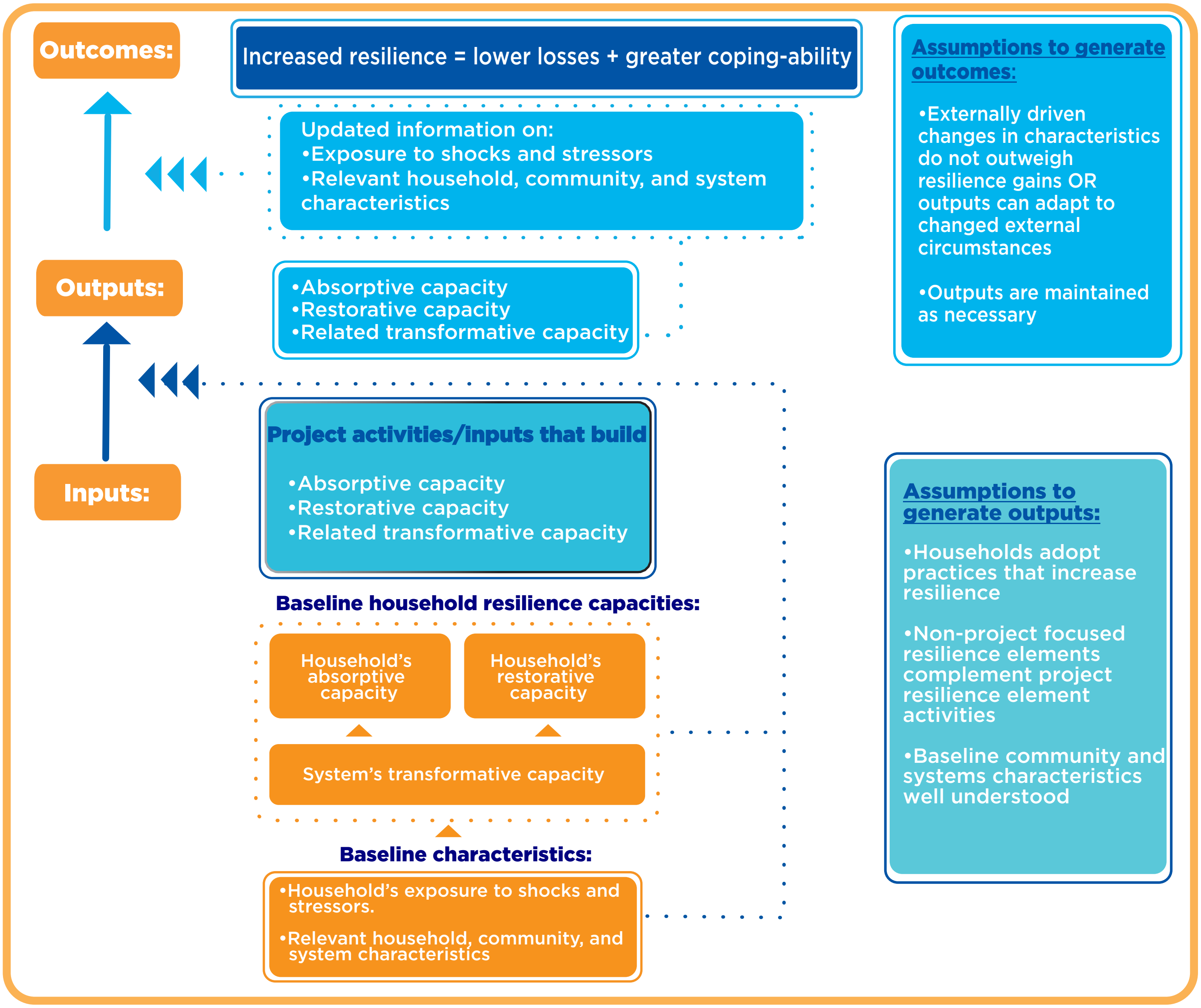
[28] See Annex 1 for additional clarifications of the developed conceptual model.

a sum of the capacity to cope minus the expected losses over the relevant time period. We also note that the above equation refers to the expected resilience of a single beneficiary. Aggregating over all those exposed to the same hazard would then simply be the sum of expected losses over all those exposed. In both the disaster risk management and climate resilience literature, the number of people, households or firms facing the same hazard is termed “exposure” (UNISDR 2016).

50. Distinguishing between expected losses due to climate change (as a function of absorptive capacity) and a separate reduction in risk (due to restorative capacity) also helps to directly link capacities to the risk reduction outcomes and is useful to develop a theory of change based on a clear causal pathway from inputs to outputs, outcomes, and impacts, as presented in Figure 4.

51. Figure 4 illustrates the theory of change for a project whose beneficiaries are households.

Figure 4: Climate resilience theory of change



52. The starting point is the **resilience context** that directly affects the baseline household resilience capacities. We need to understand the larger context and relevant baseline characteristics of households, the community, and systems in order to develop critical assumptions and determine which data need to be collected for M&E.

Note: Households belong to multiple systems that may be relevant for measuring resilience, such as the eco-system and the market system, and that are part of the community. Households face multiple shocks and slow-changing stressors, of which weather shocks and uncertain future climate are just two.

53. The **baseline household resilience capacities** depend on the relevant resilience elements that generate absorptive, restorative, or related transformative capacities. For absorptive capacity, this might include access to weather and climate-change related information **(preparedness and learning)** and indicators of income diversification **(diversification)** at the household level, local emergency response plans **(preparedness)** and flood control infrastructure **(protection)** at the community level, and personnel of watershed management committees trained in analyzing weather data **(learning)** or the municipal government having installed climate-resilient sewage pipes **(protection)** at the system level. For restorative capacity, this might include participation in insurance schemes **(recovery)** and participation in dense social networks that provide informal insurance **(options)** at the household level, a back-up generator to ensure electricity supply to critical infrastructure and services such as hospitals **(redundancy)** at the community level, and the watershed management committee having equipment to repair damaged infrastructure **(recovery)** at the system level. The system-level transformative capacity affects both the households' absorptive and restorative capacities.

54. A project's **activities/inputs** that increase resilience elements **will generate resilience outputs** (increased resilience capacity). The effectiveness of generating resilience outputs is mediated by both baseline characteristics and resilience capacities and depends on relevant assumptions as outlined in Figure 4.

Theory of change: from inputs to outputs

In a project with the objective of increasing resilience to floods, project activities and inputs generate outputs of community emergency response protocols, an early flood warning system, and investments in flood-control structures. These outputs increase the level of **learning, preparedness, and protection** in the covered communities, thereby increasing **absorptive capacity.** The project activities and inputs also generate, as outputs, mechanisms to improve the targeting of humanitarian relief in the event of floods and new equipment to repair flood damage. These outputs increase **recovery and reconstruction**, thereby increasing **restorative capacity**.

55. Climate resilience outputs (increased resilience capacity) will generate **climate resilience outcomes (fewer losses and greater coping ability)**. Again, the effectiveness with which increases in resilience capacities generate outcomes is mediated by the external environment and depends on relevant assumptions as outlined in Figure 4. We stress that different activities will generate different causal pathways. For instance, for some projects there may be intermediate and final outputs, or intermediate and final outcomes that need to be identified. For instance, a project to increase local emergency response may first start with a study on the best options for increasing response, followed by discussions with community members, resulting in a final set of activities to achieve increased local emergency response capacity. The resulting plan of activities would then be an intermediate output.

Theory of change: from outputs to outcomes

In the above-mentioned flood project, the achieved increase in absorptive capacity will lead to fewer people injured and lives lost due to floods, and to reduced public and private property damage. Fewer losses are due to 1) more timely early flood warnings enabling community leaders to execute flood preparation plans before the event occurs and advise those living in flood-prone areas to relocate before the floods come and 2) reduced damage to public and private infrastructure protected by flood control structures. The increased restorative capacity may lead to a swifter, more cost-effective return to pre-hazard growth levels due to 1) relief distributed in a timely manner to those actually in need and 2) quicker repair of damaged infrastructure. In addition, the promotion of activities that build transformative capacity including, for example, risk-sensitive land-use planning and flood zoning as well as nature-based solutions (NBS), have the potential to create a systemic shift in the way climate risks are managed.

56. Greater resilience will lead to **impacts** on beneficiaries' well-being, enabling them to maintain their productive activities and leading to higher overall incomes as well as less variable incomes, despite climate shocks and stresses. For many projects, it will not be possible/cost effective to trace project activities all the way through to the level of impacts.

57. The above is based on a simple causal pathway, where activities generate outputs, outcomes, and impacts. In many projects, the causal pathway will include more steps before outcomes and impacts are realized. For instance, many projects generate knowledge products, which are intermediate outputs and would then need to be utilized before a final output is reached (e.g., knowledge products feeding into climate-resilient infrastructure design, which would then be the climate resilience output). Similarly, many projects include activities aimed at developing or updating policy and institutional and legal frameworks as intermediate outputs, which would require operation mechanisms and funding to generate the output of a policy framework that is operational. Finally, certain projects aim at providing incentives and capacity-building for private sector agents to adopt climate-resilient practices or increase investments in climate-resilient infrastructure. The design and implementation of incentives are intermediate output activities that occur before achieving the climate resilience outputs of private sector adoption of climate-resilient practices and investments. In all of these cases, the initial activities (knowledge products; policy, legal and regulatory changes; incentives for private sector actions) generate only intermediate climate resilience outputs.

4.2 Incorporating climate resilience elements within projects

58. In line with the work countries are currently advancing on establishing climate-resilient and low-carbon development pathways that are consistent with the Paris Agreement objectives, we propose the following steps to incorporate climate resilience concepts and elements into projects and to define relevant climate resilience metrics:

I. **Identify climate-related risks,** in particular

a. Define the boundaries of the project.
b. Define the lifetime of the project and the financed assets.
c. Define current and projected exposure to extreme weather shocks/hazards (e.g., drought, flood, hail, high temperatures) and slow-onset events, including projected changes in their frequency and intensity (distribution) within the lifetime of the project and the financed assets.
d. Define projected exposure to permanent changes (day- and night-time average temperatures, shifts in the distribution of precipitation, shifts in the seasonality of temperatures and rainfall) within the lifetime of the project and the financed assets.

II. **Identify and assess the key systems within which beneficiaries operate, and which affect the climate resilience of beneficiaries,** in particular

a. For each identified system, determine critical context variables on which data needs to be collected at baseline, at the end of project implementation, and/or during project lifetime, and monitored along the way.
b. Identify the links between each system and the beneficiaries.
c. Identify trade-offs and conflicts that may arise for and between beneficiaries and the systems in which they operate.

III. **Integrate climate-related risks and systems characteristics into the theory of change**

a. Identify the climate resilience element(s) that are involved in linking inputs/activities to outputs, for instance

- Agriculture: Investment in small-scale irrigation infrastructure and activities to establish a water-user association (inputs/activities) and generate N hectares of irrigable area and a staffed water-user association (outputs). The small-scale irrigation infrastructure and management are **robust** and potentially **flexible** in the face of extreme weather events, thereby increasing **absorptive capacity.**

- Water: Investment in upgraded drainage systems in all major watersheds, including the use of nature-based solutions (NBS), built to be cost-effectively repaired and retrofitted in the future as necessary (activity), leads to a drainage system (output) that **protects** lives and public infrastructure and is more **robust** regarding climate extremes, increasing **ab-**

sorptive-related transformative capacity. Building design and materials for cost-effective repair increases **restorative-related transformative capacity.**

b. Articulate the main assumptions that need to be met for activities to generate outputs, for instance

- Agriculture: Sufficient water for the irrigation system to function even during dry/drought years **(robustness, learning/awareness)**; management system has knowledge of and incorporates the potential impact of weather shocks and climate change on the irrigation system **(learning/awareness).**

- Water: Design of drainage system incorporates all relevant available evidence **(learning/awareness)** into climate-change projections, including testing for sensitivity in order to account for uncertainty in future climate change. Designs for cost-effective repair and retrofitting are based on best available evidence of current and future climate changes **(reparability, building back better, learning/awareness).**

c. Identify the resilience capacities that are involved in linking outputs to outcomes, for instance

- Agriculture: Small-scale irrigation infrastructure leads to higher, more stable, and more diversified crop income. This leads to **fewer** crop income **losses** in extreme weather conditions or slow-onset events such as continuously increasing temperatures.

- Water: Upgraded drainage infrastructure reduces losses associated with injuries, mortality, and property damage when floods strike, and it **reduces losses** associated with disruption in public services. Ability to retrofit **reduces** future **losses**. Ability to quickly repair damages increases the **ability to cope** with extreme weather shocks.

d. Articulate the main assumptions that need to be met for outputs to generate outcomes, for instance

- Agriculture: Management of irrigation systems effectively enforces usage rules and undertakes maintenance as required **(prepared and robust)**; and farmers have the necessary resources **(labor, cash/credit, knowledge systems)** to profitably grow crops in their irrigated fields.

- Water: Drainage system financing available in a timely manner for repairs **(recovery)**; management continually updates climate information to determine need for retrofitting **(managing slow variables and feedback)** and has funds for retrofitting. Natural resource management and property rights information systems support drainage system operation.

e. Identify the link between outcomes and impacts, for instance

- Agriculture: Higher, more stable, and diversified crop income increases expected resilience, leading to higher consumption per capita and a higher quality, more diverse diet, and reduces intra- and inter-annual fluctuations in consumption.

- Water: Reduced damage to people and public and private infrastructure, combined with less costly recovery, all increase expected resilience, leading to an increase in the ability of the public sector to ensure continuous provision of public services, and greater and more stable profitability of private sector actors reliant on public infrastructure.

f. Articulate the main assumptions that need to be met for outcomes to generate impacts, for instance

- Agriculture: Farmers have access to markets, at reasonable transactions costs, both to sell new crops and purchase nutritious foods not produced at home. Farmers have a number of **options** to market their crops (locally, nearest town, government agency); farmers are part of networks (are **connected/integrated**), enabling them to access different markets at reasonable cost even during/after extreme weather events (making them **robust** regarding extreme weather events). The above assumptions are a function of market systems, agricultural policies, and knowledge systems.

- Water: Zoning and other relevant regulations incorporate updated drainage system characteristics **(learning, integration/connectedness)** when approving new public and private land investments so that those investments and the drainage system are **protected**; information collected and analyzed on the need to repair and/or adapt damaged drains **(managing feedback)**, and a budget available to repair and/or adapt damaged sections. The above assumptions are a function of property rights and knowledge systems.

59. Incorporating these steps, as illustrated in Figure 5 below, into the preparation of IDB projects will facilitate identifying elements and measures that increase the climate resilience of projects and the climate resilience that is built through specific projects (climate resilience *of* and *through* projects).

Figure 5: Steps to incorporate climate resilience within projects and to define relevant metrics

Step 1: Identify climate-related risks

a. Define the boundaries of the project.
b. Define the lifetime of the project and the financed assets.
c. Define current and projected exposure to extreme weather shocks/hazards and slow-onset events, including projected changes in their frequency and intensity (distribution) within the lifetime of the project and the financed assets.
d. Define projected exposure to permanent changes within the lifetime of the project and the financed assets.

Step 2: Identify and assess the key systems within which beneficiaries operate and that affect the resilience of beneficiaries

a. For each identified system, determine critical context variables on which data needs to be collected and monitored.
b. Identify the links between each system and the beneficiaries.

Step 3: Integrate climate-related risks and systems characteristics into the theory of change

a. Identify the climate resilience element(s) that are involved in linking inputs/activities to outputs.
b. Articulate the main assumptions that need to be met for activities to generate outputs.
c. Identify the resilience capacities that are involved in linking outputs to outcomes.
d. Articulate the main assumptions that need to be met for outputs to generate outcomes.
e. Identify the link between outcomes and impacts.
f. Articulate the main assumptions that need to be met for outcomes to generate impacts.

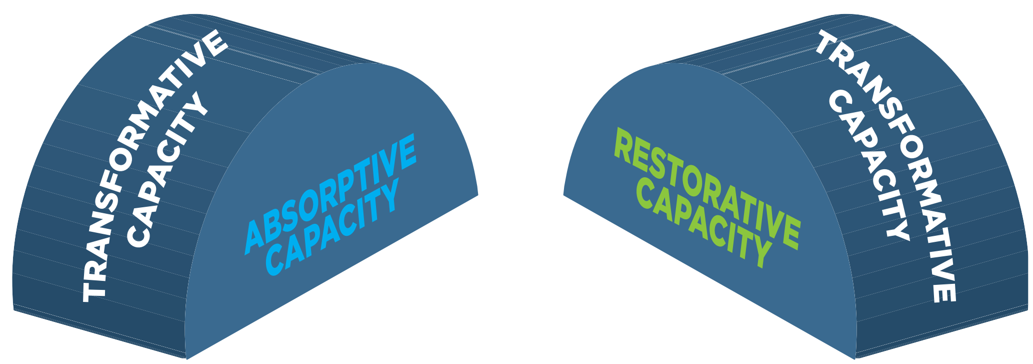
4.3 Thinking about multi-dimensionality, fitting the purpose, and context-specificity

60. It is important to mention three additional aspects that need to be considered when defining climate resilience indicators in a development project.

61. First, climate resilience is **multi-dimensional**: Most projects will not cover all possible dimensions of climate resilience. As illustrated in Figure 6, the conceptual framework proposed in this document divides this "multi-dimensionality" of climate resilience into the two climate resilience capacities, absorptive capacity and restorative capacity, and the transversal transformative capacity, which could be either absorptive- or restorative-related.

62. To illustrate, imagine a rotated half-cylindrical shape with absorptive capacity on one side and restorative capacity on the other side. The larger overarching top side corresponds to transformative capacity, which can apply, in specific cases, to both absorptive and restorative capacity. The key task when defining climate resilience indicators for a specific project or program is then to identify which dimensions of climate resilience are really influenced by the project and which combination of indicators best describes the change in climate resilience that is to be measured.

Figure 6: Dimensions of climate resilience



63. Second, climate resilience metrics must be **fit-for-purpose**: We need to define early on how we can establish that climate resilience has been enhanced by project activities, what exactly we need to measure or simulate, for how long, and whether sufficient financial and human resources will be available for monitoring changes in climate resilience.

64. Following the logic for climate resilience metrics presented in this conceptual framework, climate resilience metrics will only fulfil their purpose if they can establish that

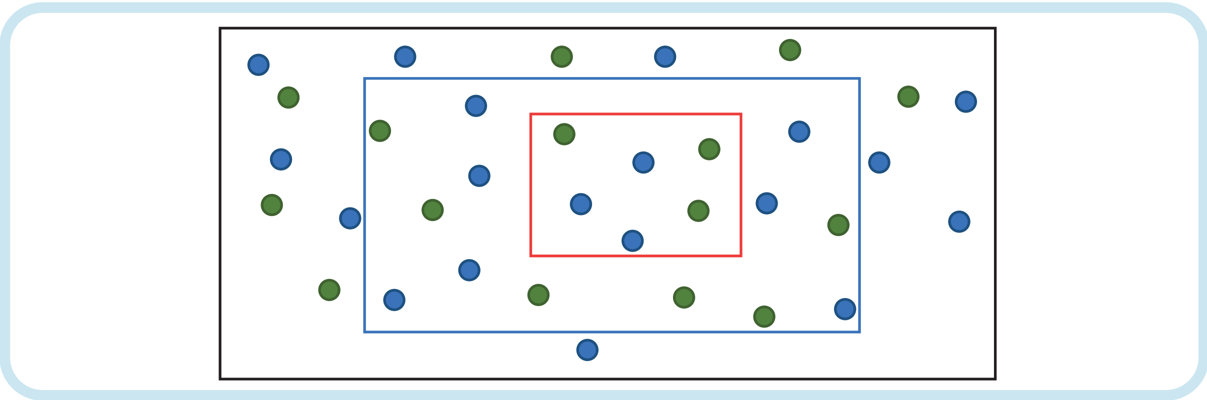
i. at the output level climate resilience capacities (absorptive or restorative capacities represented by specific climate resilience elements) have been enhanced and

ii. at the outcome level climate resilience has been increased as measured by reduced losses or enhanced coping ability.

65. Following this logic, climate resilience indicators may be on different levels of the results chain than standard results indicators in development operations that are not based on this conceptual logic. For example, the number of parcels covered by modernized registration and cadaster systems may be an outcome indicator in an operation aimed at modernizing registration and cadaster systems. When looking at climate resilience, however, this is considered an intermediate output, since the registration and cadaster systems increase tenure security and provide incentives to invest in land to protect cropland from the negative impacts of climatic shocks and stressors and increase robustness. If the systems are in place (intermediate climate resilience output), the next step will be for the owners of the parcels to actually make investments (e.g., drains, bunds, terraces, irrigation systems) to increase protection and robustness of crop production (climate resilience output: enhanced absorptive capacity). This will reduce losses at the outcome level.

66. These are important aspects to guide the selection of the most appropriate set of metrics that best capture the "dimensions of climate resilience" included in the project. This is represented in Figure 7, which illustrates a hypothetical case in which, from an initial list of 34 potential indicators of climate resilience (black frame), only six indicators are included in the project's monitoring plan (red frame).

Figure 7: Climate resilience metrics space



Note: The blue dots in this illustration represent absorptive capacity-related indicators, the green dots represent restorative capacity-related indicators. The outside **black frame** corresponds to the space of all possible climate resilience indicators for a certain type of project, the inner blue frame delineates all possible climate resilience indicators for the specific project, and the red frame corresponds to the climate resilience indicators that were selected and included in the specific project's monitoring plan.

67. Third, climate resilience metrics must be **context-specific**: While harmonization and comparability between climate resilience outcome indicators is desirable, e.g., to facilitate comparisons in the evaluation of projects, climate resilience metrics will only be comparable between projects with similar activities, baseline conditions, and contexts (for example drought and/or flood measures in a region with similar physical watersheds, socio-economic characteristics, and anticipated climate risks). Similarly, connecting climate resilience results achieved at the project level within projects of different financing agencies to national or regional sector targets is a challenge. International funds and bilateral and multilateral agencies manage different metric systems for climate resilience that are not necessarily compatible or comparable, also within and across sectors, since they might be measuring different dimensions of climate resilience. To link project-level results to national or regional sector targets, additional efforts would be needed to establish not only the links but also an integrated national system to track climate resilience advances at the national/sub-national levels. This is becoming even more relevant with many countries in the LAC region starting to think about long-term adaptation plans in line with a climate-resilient development pathway.

68. The "art" of choosing the "right" indicator is thus about **selecting the most suitable combination of metrics that, to the extent possible, can be expected to describe the change in climate resilience** of the specific system due to the project (the ones within the red frame in Figure 7).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5.

Examples of climate resilience opportunities and results indicators across different sectors

69. In the below sector notes, we illustrate (intermediate) output and outcome indicators that can be used to monitor context-specific activities to seize climate resilience opportunities in the sectors of agriculture and natural resources management, energy, fiscal policy and management, housing and urban development, transport, water, and sanitation. The indicators serve as examples to illustrate the concepts presented in this technical note and will have to be adapted to match the specific activity and context.

70. As described in the conceptual framework presented in this note, climate resilience output indicators need to establish that climate resilience capacities (absorptive or restorative capacities represented by specific climate resilience elements) have been enhanced. Climate resilience outcome indicators will need to measure how climate resilience has been increased as measured by reduced losses or enhanced coping ability. The indicators presented in the following table strictly follow this logic and may be on different levels of the results chain than standard results indicators in development operations that are not based on this conceptual logic. For example, the number of parcels covered by modernized registration and cadaster systems may be an outcome indicator in an operation aimed at modernizing registration and cadaster systems. When looking at climate resilience, however, this is considered an intermediate output, since the registration and cadaster systems increase tenure security and provide incentives to invest in land to protect cropland from negative impacts of climatic shocks and stressors and to increase robustness. If the systems are in place (intermediate climate resilience output), the next step will be for the owners of the parcels to actually make investments (e.g., drains, bunds, terraces, irrigation systems) to increase protection and robustness of crop production (climate resilience output: enhanced absorptive capacity). This will reduce losses at the outcome level.

71. We have grouped project activities into broader categories to facilitate the ability of operational teams to quickly identify those indicators that could be used to measure climate resilience for relevant components and activities of a project. These categories are 1) preparatory/planning activities (knowledge products), 2) policy, institutional, and regulatory activities, 3) provision of infrastructure, and 4) service provision and diffusion of technology.

72. For each sector, tables with indicators have been generated. In each case, the first table presents a group of illustrative indicators for climate resilience and a comparison with regular development indicators that do not consider climate resilience. Indicators presented are context-specific and in some cases have been constructed based on projects approved at the IDB in the last five years. The purpose of this first table is to illustrate how the proposed framework could be used in the development of climate resilience indicators for individual sector projects for the activity categories mentioned above. Because the main focus has been on the use of the framework, some of these indicators are not necessarily SMART. Moreover, it is important to highlight that each indicator will have to be accompanied by additional information on how to interpret it, a complementary definition of terms to help establishing a context, and monitoring and evaluation guidelines/parameters.

73. In addition to the first table, subsequent tables provide an extensive, indicative list of more general indicators following the same classification. The main purpose behind presenting these additional tables, is for this set of general indicators to serve as an "initial base" that can be adapted to the specific projects' context and purpose of measurement.

5.1 Agriculture and natural resources management

74. Agriculture and natural resources are highly vulnerable to climate change and natural disasters. Climate hazards, including higher temperatures, changing seasonal patterns of temperature and rainfall, and increasing frequency and severity of weather extremes impact agricultural productivity and pose challenges for the governance of natural resources. The management of climate risks in agriculture, the sustainable use of natural resources, and the incorporation of best available evidence on weather extremes, climate variability, and future climate change can reduce vulnerabilities in the sector and enhance climate resilience. Considering relevant climate resilience elements in the design of projects will lower expected losses and increase coping ability. By lowering losses from extreme climate events, by facilitating shifts in farming practices to accommodate slower-moving climate changes, and by enhancing the ability to cope with weather shocks when they occur, climate resilience will contribute to the well-being of rural families.

75. The following table, based on information from projects approved at the IDB, presents a group of illustrative indicators for climate resilience and a comparison with regular development indicators that do not consider climate resilience.

Table 6: From regular development indicators to climate resilience indicators in the sector of agriculture and natural resources management

Climate resilience opportunity	Project activity	Example of a related indicator that does not yet consider adaptation and climate resilience	Aspects of climate resilience that could be included	Illustrative example of a climate resilience indicator
Preparatory activities/ sector wide-planning activities	Design local water-use plans that prioritize irrigation investments	Output indicator: # of local water-use plans developed	Include and continually update climate-change projection information in local water-use plans **(learning)** to prioritize irrigation investments, in part, on climate resilience considerations such as **robustness**, **redundancies**, and **reparability**	Climate resilience output indicator: # of local water-use plans developed that include sections that address climate hazards and resilience elements, e.g., **robustness, redundancies**, and **reparability**
	Design and implement an information dissemination campaign outlining scope and benefits of restoring forests damaged by bark beetles	Output indicator: Campaign to disseminate scope/ benefits of restoration conducted	Ensure that campaign materials include information on climate hazards **(learning)** and the role of restoration to increase climate resilience elements **(robustness, protection)**	Climate resilience output indicator: The material of the campaign to disseminate scope/benefits of restoration includes # of sections that detail the link between sustainable forest management and resilience elements **(learning, robustness, protection)**
	Institutional strengthening for provincial institutions	Output indicator: # of provincial staff trained	Training provincial institutions in climate change-related topics to enhance **preparedness** and **integration/connection** between provincial institutions and with the national government and to enable **complex adaptive systems thinking** and **recovery**	Climate resilience output indicator: # of provincial staff trained in topics related to climate-change **preparedness, integration/ connection, complex adaptive systems thinking**, and **recovery**
Sector policy, legal, and institutional support activities	Establish five producer organizations	Output indicator: # of established producer organizations	Ensure that producer organizations are set up in a manner that increases restorative capacities of producers, e.g., offering **recovery** services	Climate resilience output indicator: # of established producer organizations offering services to **recover** from climatic shocks and stressors
	Establish seven regional offices to monitor bark beetle	Output indicator: Pest monitoring and forest restoration system operational	Regional and central office develop mechanisms for sharing climate data and analyses **(learning)**, develop integrated emergency response plans **(preparedness)**	Climate resilience output indicator: The pest monitoring and forest restoration system includes documented mechanisms that allow for data sharing **(learning)** and integrated emergency response plans **(preparedness)**
		Outcome indicator: Reduction in the average size of bark beetle outbreaks throughout the country	Operational system (partly comprised of different outputs) increases **transformative absorptive capacity** and reduces size of outbreaks	Climate resilience outcome indicator: Reduction in the size of bark beetle outbreaks throughout the country after extreme climate event **(increased coping ability)**
Climate-related technologies and agricultural services	Support for applied agricultural research to develop new agricultural technologies	Output indicator: # of beneficiary farmers who received technology packages	Current and future technologies are based on available climate-change predictions **(learning** about **robustness, protection,** etc.)	Climate resilience output indicator: # of beneficiary farmers who received technology packages that increase **robustness** of agricultural production and provide **protection** for agricultural land and assets (based on research evidence) in the project area
		Outcome indicator: # of farmers adopting new technologies that were developed	Technology research and development that considers climate change can increase **absorptive and restorative capacities**, e.g., by increasing farming system robustness, protecting soil quality or increasing diversification	Climate resilience outcome indicator: # of farmers adopting **robust** technologies that increase production **diversity**
Climate-resilient rural infrastruc-ture	Construction and rehabilitation of irrigation systems	Output indicator: # of hectares of farmland covered by irrigation infrastructure	The designs of the irrigation systems should incorporate available climate projections **(learning)** and be built to be **robust,** and easily **reparable**	Climate resilience output indicator: # of hectares of farmland covered by irrigation infrastructure built to be **robust** to 100-year storm events and **reparable** at costs under 5% of its cost
		Outcome indicator: Average increase in land productivity (crop and livestock) due to irrigation infrastructure	Management, maintenance, and operation of irrigation infrastructure increases **absorptive capacity** of farmers so that they face relatively fewer losses in dry/drought years; greater **restorative capacity** enables timelier repair and also reduces production losses after extreme weather event	Climate resilience outcome indicator: Reduced average production losses during extreme drought events due to irrigation infrastructure **(reduced losses)** Reduction in # of days/expenditures needed to repair damaged infrastructure **(increased coping ability)**

76. Below is a collection of additional indicators, some of them more general, organized by type of activity to illustrate the variety of climate resilience metrics and to inspire and guide the development of context- and project-specific indicators.

Table 7: Collection of (more general) illustrative climate resilience indicators for the sector of agriculture and natural resources management

	Preparatory activities/sector wide planning activities that increase preparedness to promote adaptation and resilience to climate change
Intermediate output indicators	**Absorptive capacity:** - # of knowledge products **(learning/awareness)** on • natural resource management and governance instruments with sections on how specific management mechanisms and governance instruments will increase absorptive capacities **(robustness, protection)** • the impact of **robust**, **protected** rural infrastructure on metrics of farmers' resilience • the impact of having access to high-quality agro-climatic information **(preparedness, flexibility, options)** on metrics of farmers' resilience • technologies/practices that increase **robustness** and **protection** on farms • local and traditional knowledge related to farm practices that are **robust** to climate shocks and stressors • pest control, sustainable forest management, and climate-resilient species with sections documenting options that increase resilience elements - # of absorptive capacity elements that have been addressed and included in capacity-building materials **(learning/awareness** about **protection, robustness, integration, lexibility)** - # of sections of analysis document for sustainable forest management options that explicitly incorporate best available evidence **(learning/awareness)** on current and future climate hazards - # of sections in materials for information dissemination campaigns **(learning/awareness)** that outline the scope and benefits to restoring forests, in which trees have been infected by insects, e.g., bark beetles, and that detail the link between sustainable forest management and climate resilience elements **(robustness, protection)** **Absorptive-related transformative capacity:** - # of knowledge documents on natural resource management and governance instruments that evaluate the relationship between weather extremes and slow-onset climate changes, absorptive resilience elements **(learning/awareness** about **protection, robustness, preparedness, managing slow variables and feedback)** and system-wide management and governance instruments - # of technologies identified **(learning/awareness)** that enable farmers to adopt **robust** practices and **protective** infrastructure to manage weather extremes and slow-onset climate change impacts across all relevant agro-ecosystems nationwide **Restorative capacity:** - # of knowledge products **(learning/awareness)** on • natural resource management and governance instruments with sections on how specific management mechanisms and governance instruments will increase absorptive capacities (**learning/awareness** about **preparedness, reparability, recovery**) • **reparability, recovery, options** of rural infrastructure • technologies/practices that increase recovery on farms • **recovery** benefits to farmers from weather insurance • **recovery** benefits to farmers from weather-sensitive social safety nets • pest control, sustainable forest management, and climate-resilient species with sections documenting options that increase resilience elements - # restorative capacity elements that have been addressed and included in capacity-building materials **(learning/awareness** about **reparability, recovery, integration, lexibility**) - # of sections of analysis document for sustainable forest management options that explicitly incorporate best available evidence (**learning/awareness**) on current and future climate hazards **Restorative-related transformative capacity:** - # knowledge documents on system-wide natural resource management and governance instruments that evaluate the relationship between weather extremes and slow-onset climate changes, restorative resilience elements **(learning/awareness about preparedness, reparability (building back better), integration, flexibility)** and system-wide management and governance instruments
Output indicators	**Absorptive capacity:** - # of absorptive resilience elements **(robustness, protection)** integrated in design documents for natural resource management investments based on relevant project knowledge products - Metrics of absorptive resilience knowledge **(robustness, protection, integration, lexibility)** of participants after capacity building exercises - # of absorptive resilience elements **(robustness, protection, diversi ication)** integrated into rural infrastructure design documents based on project knowledge products - # of absorptive resilience elements **(learning, robustness, protection, diversi ication)** integrated into rural service provision design documents based on project knowledge products - # of rural service providers integrating high quality agro-climatic data **(learning, preparedness)** into service provision - # of absorptive resilience elements from traditional and local knowledge sources **(robustness, protection, diversi ication, lexibility)** integrated into rural service provision design documents - # of absorptive resilience elements **(robustness, protection, diversi ication)** integrated into rural technology promotion based on project knowledge products - # of climate resilient **(robustness, protection)** species contributed to a seed bank - # of drought resistant seed varieties or short-maturing seed varieties for delayed onset of rain that farmers have available **(robustness, preparedness, protection)** **Absorptive-related transformative capacity:** - # of absorptive resilience elements **(protection, robustness, preparedness, managing slow variables and feedback)** integrated into system-wide natural resource governance frameworks and regulations **Restorative capacity:** - # of restorative resilience elements **(preparedness, reparability, recovery)** integrated in design documents for natural resource management investments based on relevant project knowledge products - Metrics of restorative resilience knowledge **(preparedness, reparability, integration, lexibility)** of participants after capacity building exercises-# of project design documents to promote purchase of weather risk insurance **(recovery)** that incorporate lessons learned from weather risk insurance knowledge products - # of safety net **(recovery)** operational documents that incorporate lessons learned from weather-sensitive social safety net knowledge products **Restorative-related transformative capacity:** - # of restorative resilience elements **(preparedness, reparability (building back better), integration, lexibility)** integrated into system-wide natural resource governance frameworks and regulations - # of absorptive resilience elements **(reparability, recovery, options)** integrated into rural infrastructure design documents based on project knowledge products - # of drought resistant seed varieties or short-maturing seed varieties for delayed onset of rain that farmers have available **(options, lexibility)**

Table 7 (continued): Collection of (more general) illustrative climate resilience indicators for the sector of agriculture and natural resources management

Support sector policy, legal, and institutional activities that enhance climate resilience by ensuring that natural resources are used sustainably and that the best available evidence on weather extremes and future climate change is considered	
Intermediate output indicators	**Absorptive capacity:** - # of farm/poor/marginalized parcels covered by modernized registration and cadaster systems, which increases tenure security and provides incentives to invest in land, including investments to **protect** cropland from negative impacts of climatic shocks (e.g., drains, bunds, terraces) and stressors and increase **robustness** of crop production in the face of climate shocks and stressors (e.g., irrigation) - # of communities with established property rights for their natural resources, which provides incentives to act collectively to invest in **robustness** and **protection** - # of farmers receiving government incentives to adopt technological innovations that increase absorptive resilience elements **(robustness, flexibility)** - # of sections in training materials **(learning/awareness)** for forest control staff on links between weather and specific pests and emergency response **(preparedness)** - # of farmers and/or communities that continually collect and update climate information to determine adaptation needs **(managing slow variables and feedback)**, e.g., choice of seeds, retrofitting of their drainage or irrigation systems **Absorptive-related transformative capacity:** - # of absorptive resilience elements **(learning, integration/connectedness, polycentric governance, protection, robustness)** specifically addressed in new or revised institutional and legal frameworks at national or sub-national levels incorporating potential impacts of weather extremes and climate change and guiding sustainable resource use - # of absorptive resilience elements **(learning, integration/connectedness, polycentric governance, protection, robustness)** specifically addressed in new/revised policy dialogue documents - # of mechanisms established for farmers and/or communities to continually update climate information to determine adaptation needs **(managing slow variables and feedback)**, e.g., choice of seeds, retrofitting of drainage or irrigation systems **Restorative capacity:** - # of restorative resilience elements specifically addressed in new/revised policy framework guiding the operation of Producer Associations (**flexibility, options** to recover, **reconstruction**) **Restorative-related transformative capacity:** - # of restorative resilience elements **(learning, integration/connectedness, polycentric governance, recovery, reparability)** specifically addressed in new or revised institutional and legal frameworks at national or sub-national levels incorporating potential impacts of weather extremes and climate change and guiding sustainable resource use - # of restorative resilience elements **(learning, integration/connectedness, polycentric governance, recovery)** specifically addressed in new/revised policy dialogue documents
Output indicators	**Absorptive capacity:** - # of poor/marginalized farm households covered by modernized registration and cadaster that have invested in land improvements that **protect** crops and increase **robustness** regarding climatic shocks and stressors - # of communities with established property rights that have invested in ensuring natural resources are **robust** and **protected** - # farmers who adopt technological innovations that increase **protection** and **robustness** - # of forest health units with equipment **(preparedness, protection)** - # of forest control staff trained to understand links between weather and specific pests and emergency response (**learning/awareness** about **preparedness**) **Absorptive-related transformative capacity:** - # of mechanisms implemented that increase **robustness** and **protection** of natural resources system-wide through **integrated** and **polycentric** governance - # of mechanisms that harmonize actions to increase absorptive capacity regionally **(integrated/connectedness, learning, preparedness, robustness)** - Documentation of climate data-sharing **(learning/awareness)** and integrated emergency response plans **(preparedness)** within a pest monitoring and forest restoration system **Restorative capacity:** - # of producer organizations offering services to recover from climatic shocks and stressors **Restorative-related transformative capacity:** - # of mechanisms implemented system-wide that increase **preparedness** and **recovery** of natural resources after a climate shock through **integrated** and **polycentric** governance - # of mechanisms that harmonize actions to increase absorptive capacity regionally **(integrated/connectedness, learning, recovery, reparability)**

Table 7 (continued): Collection of (more general) illustrative climate resilience indicators for the sector of agriculture and natural resources management

	Promote the provision of **climate-related technologies and agricultural services** (e.g., agro-climatic information, insurance)
Intermediate output indicators	**Absorptive capacity:** - An incentive-system is in place for farmers to adopt innovations that enable them to adopt **robust**, **diversified** technologies and sustainable agricultural practices - An incentive-system is in place for private forest owners to adopt innovations that enable them to adopt **robust, diversified** technologies and sustainable forest management practices - # of applied agricultural research projects explicitly addressing how technology can increase climate resilience, e.g. **protection, robustness**, and **diversification** - # of scholarships awarded to research fellows with research agenda that explicitly includes the use of technologies for learning about climate hazards **(learning/awareness)** **Restorative capacity:** - An incentive-system is in place for farmers to adopt innovations that allow more timely **repairs** after a climate shock - An incentive-system is in place for private forest owners to adopt innovations that allow more timely **repairs** after a climate shock - # of applied agricultural research projects explicitly addressing how technology can increase climate resilience, e.g. **flexibility, diversification,** and **reparability** - # of scholarships awarded to research fellows with research agenda that explicitly includes the use of technologies for learning about climate hazards **(learning/awareness)**
Output indicators	**Absorptive capacity:** - # of farmers and other relevant stakeholders (e.g., traders) with access to quality agro-climatic information **(learning, preparedness, flexibility)** - # of hectares covered by transferred technologies that increase **protection, robustness,** and **diversification** - Funds spent for climate resilience-related research **(learning/awareness)** as % of GDP - # of new technologies developed **(learning/awareness)** through research, explicitly linked to increasing climate resilience elements - # of farmers adopting **robust** technologies that increase diversified income **Absorptive-related transformative capacity:** - # of absorptive resilience elements **(integration/coordination, robustness)** in design documents of modernized logistics and bulking infrastructure throughout the value chain **Restorative capacity:** - # of hectares covered by transferred technologies that increase **reparability** - # of farmers with weather risk insurance **(recovery, flexibility)** - # of farmers covered by weather-responsive social safety net programs **(recovery, flexibility)** - Funds spent for climate resilience-related research as % of GDP - # of new technologies developed **(learning/awareness)** through research, explicitly linked to increasing climate resilience elements - # of data analysis protocols regularly produced by hydro-meteorological stations that generate **learning** and provide early warning of extreme rainfall and temperatures so that farmers are **prepared** and can **flexibly** respond to warnings **Restorative-related transformative capacity:** - # of absorptive resilience elements **(integration/coordination, recovery, redundancies)** in design documents of modernized logistics and bulking infrastructure throughout the value chain
Outcome indicators	**Reduced losses due to absorptive capacity:** - Actual or expected decrease in crop yield and livestock losses due to climatic shocks and stressors from increased household-level adoption of transferred technologies and practices - Actual or expected avoided losses in crop yield and livestock losses due to access to high quality agro-climatic data - Actual or expected decrease in crop and livestock income due to fewer disruptions, modernized logistics, and bulking system - Reduction in the size of pest outbreaks throughout the country/in specific regions/in the project area after an extreme climate event - Reduced # of hectares with insufficient irrigation water in dry/drought years due to information and warnings from hydro-meteorological stations **Enhanced coping ability due to restorative capacity:** - Reduction in # of days/expenditures needed to repair damaged infrastructure - Actual or expected decrease in crop and livestock income losses due to speedier recovery of any damages to modernized logistics and bulking system - Reduction in # of days to repair on-farm infrastructure and invest in next-season inputs due to weather risk insurance - Reduction in value of assets sold after climate shocks

Table 7 (continued): Collection of (more general) illustrative climate resilience indicators for the sector of agriculture and natural resources management

	Promote the **provision of climate-resilient rural infrastructure** (irrigation, drainage, etc.) and **climate-resilient natural resources** and practices (e.g., specific species, sustainable agricultural practices, sustainable forest management)
Intermediate output indicators	**Absorptive capacity:** - # of absorptive resilience elements contained in project incentives' design/promotional materials related to household-level adaptation-related infrastructure **(protection, robustness, diversification)** - # of absorptive resilience elements addressed in the design of a pilot incentive program to increase sustainable agricultural practices by farmers **(robustness, protection, diversification)** - # of sections in program documents detailing the link between sustainable agricultural practices and resilience elements **(robustness, protection, diversification)** - # of absorptive resilience elements addressed in the design of a pilot incentive program to increase sustainable forest management practices by private forest owners **(robustness, protection, diversification)** - # of sections in program documents detailing the link between sustainable forest management practices and resilience elements **(robustness, protection, diversification)** - # of sections in program documents detailing the link between coastal protection and restoration and resilience elements **(protection, robustness)** **Restorative capacity:** - # of restorative resilience elements contained in project incentives' design/promotional materials related to household-level adaptation-related infrastructure **(reparability, redundancies)**
Output indicators	**Absorptive capacity:** - # of absorptive resilience elements contained in public rural infrastructure design documents **(protection, robustness)** - # of hectares of farmland protected by drainage, soil and water conservation structures, agro-forestry **(protection, robustness, diversification)** - # of hectares of farmland covered by irrigation infrastructure **(protection, robustness, diversification)** - % of forests covered by climate-resilient species of trees **(protection, robustness)** - # of climate-resilient trees planted **(protection, robustness)** - # of hectares where sustainable agricultural practices are applied **(robustness)** - # of crops/livestock species **(diversification)** - # of hectares where sustainable forest management practices are applied **(robustness)** - # of hectares of restored coastal ecosystems **(robustness, protection)** **Restorative capacity:** - # of restorative resilience elements contained in public rural infrastructure design documents **(flexibility, modularity, redundancies, reparability)** - Metrics of on-farm infrastructure constructed with locally available materials, built to be quickly **repaired**
Outcome indicators	**Reduced losses due to absorptive capacity:** - Actual or expected decrease in crop yield and livestock losses due to climatic shocks and stressors from increased household-level adoption of absorptive resilient infrastructure - Actual or expected decrease in crop and livestock income due to absorptive resilient public infrastructure - Reduced yield losses due to weather shocks or higher temperatures for farms that follow sustainable agriculture practices - Reduced forest damage due to climate shocks or climate-related pests - Reduced area of forest affected by climate-related pests - Reduced forest density loss due to climate shocks or climate-related pests - Reduced damage to property and assets for beneficiaries near restored coastal ecosystems when exposed to a climate shock **Enhanced coping ability due to restorative capacity:** - Reduction in # of days/expenditures needed to repair damaged public and private infrastructure - Higher crop incomes in the season following a climate shock vis-à-vis those without access to restorative resilient public and private infrastructure

5.2 Energy

77. Energy systems (this includes power generation, transmission, and distribution infrastructure) are vulnerable to sudden and destructive effects caused by extreme weather events, as well as gradual impacts such as higher heating and cooling demand, and sea-level rise that affects coastal power infrastructure. Therefore, to address these impacts, observations and predictions systems/platforms must be in place, as well as research and practice on energy sector adaptation, which is particularly important in those countries that lack wide coverage of hydro-meteorological data and the capacity to analyze that data. Climate hazards for energy systems include, among others, higher extreme temperatures and heatwaves; hurricanes and extreme events; and increases/changes in patterns of frequency and intensity of rainfall, such as (i) torrential rainfall and floods and (ii) droughts. In connection with these, some of the more relevant impacts of climate change include (i) recession of glaciers in the tropical Andes affecting hydroelectricity, (ii) destabilization of hydrological cycles in major basins, affecting stream flows and in turn the availability of water for thermal generation plant cooling, (iii) changes in wind patterns and clouds formations, (iv) sea-level rise and coastal erosion, putting exposed infrastructure at increased risk, (v) increase in number of stronger storms and torrential rains in mountainous areas that affect transmission infrastructure, and (vi) greater variation, or unpredictability, of hydropower generation due to shifting weather patterns.

78. There are various measures that can be taken to reduce sector vulnerabilities to the above-mentioned impacts and to enhance climate resilience, including (1) diversifying and better integrating available energy sources and storage, e.g. renewables, to ensure continuity in energy service provision, (2) enhancing planning of energy sources including the use of decision support planning systems for the management of key uncertainties, including climate change, (3) increasing available energy through improvements in energy efficiency and reduced losses, which can provide robustness to climate shocks, (4) greater regional integration to diversify energy sources and provide options for flexible response to climate shocks, (5) making more resilient transmission and distribution energy infrastructure, (6) conserving natural capital, in particular in the recharge areas of watersheds that provide stream flow for hydropower, and (7) strengthening institutional capacities that are needed for implementing the activities described in 1 to 6. NBS can reduce risk and increase efficiency in each stage of energy service delivery, from production to consumption. Investments in ecosystems upstream of hydropower plants can help secure a reliable water supply for electricity generation, mitigate siltation in reservoirs, and increase the lifespan of hydropower equipment; strategic conservation of ecosystems surrounding transmission lines can help protect transmission infrastructure from natural hazards such as landslides, flooding, and wildfire; and green roofs and green spaces can mitigate extreme urban heat, reducing the need for indoor cooling *(see Nature-based solutions in Latin America and the Caribbean: Support from the IDBG,* IDB, forthcoming).

79. The following table presents a group of illustrative indicators for climate resilience and a comparison with regular development indicators that do not consider climate resilience from projects approved at the IDB.

Table 8: From regular development indicators to climate resilience indicators in the energy sector

Climate resilience opportunity	Project activity	Example of a related indicator that does not yet consider adaptation and climate resilience	Aspects of climate resilience that could be included	Illustrative example of a climate resilience indicator
Preparatory/ sector-wide planning activities	Development of technical studies during project preparation	Intermediate output indicator: Feasibility studies for hydroelectric plant conducted	Hydroelectricity is sensitive to changes in the amount of water available, in particular during the dry season and in the Andean region, where tropical glaciers are relevant run-off contributors to the watershed hydrological balances. By including specific climate-change impacts studies on the watershed hydrology and creating different future scenarios of water availability, the design of hydroelectric plants can be more **robust**. Designs that also incorporate **redundancies and constant/long-term monitoring** of available flows (*ex-ante* actions) will increase **absorptive capacity** as these will help facilitate resource-use planning.	Intermediate climate resilience indicator: Climate-change impacts study on potential changes to local watershed hydrology conducted
	Strengthening institutional capacity to deal with uncertainties in the energy sector	Output indicators: # of operators trained on topics to improve system's performance # of resource-planning professionals at the plant level with improved resource-planning skills	Capacity-building of operators is one of the key activities that can significantly help reduce the vulnerability of electricity networks to climate change. Specifically, training can contribute to building **awareness and preparedness** and will incentivize **learning,** it will also bring **complex-adaptive-systems thinking.** Along these lines, strengthening institutional capacity to deal with uncertainties will increase **absorptive capacity** and **restorative capacity**	Climate resilience output indicators: # of operators trained on topics to improve system performance and downtime with a focus on climate shocks # of resource-planning professionals at the plant level capable of using decision support planning systems that incorporate all uncertainties, including climate change
Institutional/ regulatory activities	Update of technical standards for the energy sector	Output indicator: # of applied updated technical standards, such as network codes or procurement criteria Outcome indicator: Fewer disruptions to energy services	Consider how relevant climate resilience elements, such as **robustness** and **protection,** can be included when updating technical rules that guide investments and activities in the energy sector	Climate resilience output indicator: # of applied updated technical standards, such as network codes or procurement criteria, that enhance infrastructure's climate **robustness** and **protection** Climate resilience outcome indicator: Fewer disruptions to energy services from climate shocks due to updated technical standards **(reduced losses)**
	Promoting public policy reform processes under consideration of climate resilience	Output indicator: # of public policy reform processes implemented in the energy sector to promote renewable energies Outcome indicator: Increased reliability of energy service provision	Ensure that public policy reforms in the energy sector are utilized as a vehicle to increase **absorptive and restorative capacities** in the sector, e.g., to ensure sector-wide **protection, reparability** etc. of energy infrastructure. This will **reduce losses** and **increase coping ability.**	Climate resilience output indicator: # of public policy reform processes implemented that promote renewable energy and enhances electricity systems' **robustness, reparability, flexibility/ redundancies** Climate resilience outcome indicators: Fewer system-wide disruptions to energy services due to climate shocks Fewer days to repair damaged infrastructure caused by climate shocks Average Service Availability Index (ASAI)

Table 8 (continued): From regular development indicators to climate resilience indicators in the energy sector

Climate resilience opportunity	Project activity	Example of a related indicator that does not yet consider adaptation and climate resilience	Aspects of climate resilience that could be included	Illustrative example of a climate resilience indicator
Climate-related technologies and service provision	Deployment of drone-based technology for the assessment of damages	Outcome indicator: Electricity system's failure diagnostics and repair time improved by 10%	The use of modern airborne robots/drones can improve a system's reparability and provides **flexibility** for operators, thereby increasing **restorative capacity** and enhancing **coping ability** at the outcome level. This is particularly key in the aftermath of a climate shock such as a hurricane.	Climate resilience outcome indicator: Electricity system failure diagnostics and repair time improved 10% when exposed to and damaged by a climate shock by (enhanced **coping ability**)
	Development and use of digital visualization platforms to monitor and assess status of transmission and distribution lines	Outcome indicator: System Average Interruption Duration Index (SAIDI) and Average Interruption Time (AIT) improved	Visualization platforms for assessing system performance in real time can help identify points that are out of service in the aftermath of a climate shock. This type of tool can also be instrumental for determining vulnerable hot spots and thus for enhancing **coping ability** at the outcome level.	Climate resilience outcome indicator: **Coping ability** of Transmission and distribution systems improved when exposed to a climate shock (measured through the SAIFI and the AIT)
	Use of new technology to improve operations and maintenance	Output indicator: # of conventional instrument transformers to improve grids' operation deployed	The use of transformative technology to improve the operation and maintenance of an electricity network can help building absorptive and restorative capacit**y** because it is made more **reliable** and can help to shorten times for repairs and improve **reparability and connectivity.** This is key for systems that are exposed to extreme events and slow-onset impacts of climate change, such as average temperature increase, that impact system performance and reliability.	Climate resilience output indicator: # of non-invasive sensors such as GMR and TMR installed in new SMART grids *GMR: Giant Magnetoresistance *TMR: Tunnel Magnetoresistance
Climate-resilient infrastructure (generation, transmission and distribution)	Installation of solar photovoltaic power plants in public buildings and schools	Output indicator: Solar power plants installed and operational Outcome indicator: Tons of GHG emissions avoided through solar panel power generation	Solar plants that are built to be **robust to climate extremes**, in particular high-velocity winds, increase **power source diversification** and could increase power system redundancies. Robust solar power plants increase **absorptive capacity,** leading **to reduced expected damage** due to extreme weather, and **reduced service disruption and associated losses**	Climate resilience output indicator: Solar power plants installed and operational built to be **robust** regarding climate shocks and easily **reparable** Climate resilience outcome indicator: Reduced expected damage to solar power infrastructure systems due to exposure to climate shocks **(reduced losses)**

80. Below is a collection of additional indicators, some of them more general, organized by type of activity to illustrate the variety of climate resilience metrics and to inspire and guide the development of context- and project-specific indicators. However, it is important to mention that this is by no means intended to be an extensive list of metrics for climate resilience in the energy sector, but rather an illustration of the framework proposed in this document. The list of indicators presented below encompasses different key aspects of climate resilience in the energy generation sector, pertaining to system design and operation, service delivery, disruptions, costs, and timescales.

Table 9: Collection of (more general) illustrative climate resilience indicators for the energy sector

	Preparatory/planning activities that increase preparedness to promote adaptation and resilience to climate change
Intermediate output indicators	**Absorptive capacity:** - # of absorptive-related resilience elements **(learning, preparedness, robustness, complex-adaptive systems thinking)** addressed in knowledge products - # of technical assistance documents covering design of **robust** and **protected** energy infrastructure - Data/monitoring system established to enable analyses of **robustness** and **protection** in infrastructure designs - # of assessments of impact of climate hazard on service providers' **robustness** and **protection** performance - # of sections in pilot project's design documents that address **preparedness, protection,** and **robustness** **Restorative capacity:** - # of restorative-related resilience elements **(reparability, recovery, redundancies)** addressed in knowledge products - # of technical assistance documents covering design of **redundant** and **easily reparable** energy infrastructure - Data/monitoring system established to enable analyses of **preparedness** and **recovery** - # of assessments of impact of climate shock on service providers' **recovery** performance - # of sections in pilot project's design documents that address **flexibility, options, reparability, recovery** **Restorative-related transformative capacity:** - Early warning system designed **(preparedness, response options and recovery)** - # of contingency plans developed that address **preparedness, response options,** and **recovery**
Output indicators	**Absorptive-related transformative capacity:** - Investment documents contain sections on investments that increase system **robustness** regarding climate shocks - Technical documentation that technology installed and operational makes the energy system more **robust** regarding climate hazards - Infrastructure design documents contain sections on **robustness** regarding climate shocks - Technical document sections documenting **interconnection, diversification** of energy sources, and **flexibility** in the design of the distribution system to manage fluctuations due to climate shocks - Evaluation sections that address **preparedness** and **robustness** **Restorative-related transformative capacity:** - Investment documents contain sections on system **integration** and **redundancies** that ensure continuity in service when exposed to a climatic shock - Technical documentation of ability to facilitate rapid **recovery** after a climatic shock - Infrastructure design documents contain sections on climate hazards **(learning)**, **redundant** components, and easy **reparability** - # of shared experiences about **recovery** response options - Evaluation sections that address **flexibility, reparability,** and **building back better**

Table 9 (continued): Collection of (more general) illustrative climate resilience indicators for the energy sector

	Institutional/regulatory activities (e.g., promote integration and sharing lessons learned on climate resilience)
Intermediate output indicators	**Absorptive-related transformative capacity:** - # of updated technical rules, such as network codes or procurement standards, that address robust and protected energy infrastructure - # of energy sector-related framework documents with sections on **preparedness** and **robustness**, and mechanisms to **integrate/coordinate** actions to increase absorptive capacity across multiple sectors **(polycentric governance)** - # of public policy reforms adopted with sections on **robustness** and **protection** - # of knowledge products with sections on **preparedness, protection,** and **robustness** - # of technical assistance documents with sections on **integration/coordination** amongst multiple sectors **(polycentric governance)** to address **protection** of energy infrastructure - Metrics developed to measure increased **integration** across relevant institutions - # of mechanisms developed to analyze data and incorporate results of analysis into policies **(complex adaptive thinking)** **Restorative-related transformative capacity:** - # of energy sector-related framework documents with sections on **reparability, redundancies,** and **recovery** options, and mechanisms to **integrate/coordinate** actions to increase restorative capacity across multiple sectors **(polycentric governance)** - # of public policy reforms adopted with sections on **reparability, flexibility/redundancies,** and **recovery** - # of knowledge products with sections on **reparability, flexibility/redundancies,** and **recovery** - # of technical assistance documents with sections on **integration/coordination** amongst multiple sectors **(polycentric governance)** to address **repair** of energy infrastructure damaged by climate shock or stressors
Output indicators	**Absorptive-related transformative capacity:** - # of applied updated technical rules, such as network codes or procurement standards, that address robust and protected energy infrastructure - # of mechanisms operationalized to **integrate/coordinate** actions across multiple sectors **(polycentric governance)** to increase absorptive capacity - # of public policy reform processes implemented that address **robust** and **protected** energy infrastructure - # of (regional) energy infrastructure and operations mechanism design documents with sections on **preparedness, protection,** and **robustness** based on knowledge products - # of mechanisms operationalized to **integrate/coordinate** actions across multiple sectors **(polycentric governance)** to address **protection** of energy infrastructure - Metrics documenting increased **integration** across relevant institutions - # of mechanisms operationalized to analyze data and incorporate results of analysis into policies **(complex adaptive management)** **Restorative-related transformative capacity:** - # of mechanisms operationalized to **integrate/coordinate** actions across multiple sectors **(polycentric governance)** to increase restorative capacity - # of public policy processes implemented that address **reparability, flexibility/redundancies,** and **recovery** - # of (regional) energy infrastructure and operations mechanism design documents with sections on **reparability, flexibility/redundancies,** and **recovery** - # of mechanisms operationalized to **integrate/coordinate** actions across multiple sectors **(polycentric governance)** to address rapid repair of energy infrastructure damaged by climate shocks and stressors

Table 9 (continued): Collection of (more general) illustrative climate resilience indicators for the energy sector

	Climate-related technologies and service provision
Output indicators	**Absorptive capacity:** - # of operational mechanisms implemented in the energy sector that increase **robustness** of service provision - # of technologies adopted and operationalized to increase **preparedness, robustness,** and **coordination/integration** of service provision **Absorptive-related transformative capacity:** - # of state-of-the-art technologies adopted system-wide to increase system's **robustness** regarding climate shocks and stressors - # of multi-sectoral coordination mechanisms implemented system-wide to increase system's **robustness** regarding climate shocks and stressors - # of sources for energy generation **(preparedness, robustness)** **Restorative capacity:** - # of operational mechanisms implemented in the energy sector that increase **recovery** of service provision - # of technologies adopted and operationalized to increase **redundancies, flexibility,** and options to **recover** **Restorative-related transformative capacity:** - # of multi-sectoral coordination mechanisms implemented system-wide to increase system's **flexibility** to **respond** and **restore** service outages caused by climate shocks and stressors - # of state-of-the-art technologies adopted system-wide to **restore** service outages caused by climate shocks and stressors - # of sources for energy generation (diversification, options)
Outcome indicators	**Reduced losses due to absorptive capacity:** - Fewer days of energy service outages when a climate shock occurs (rural and urban areas) **Reduced losses due to absorptive-related transformative capacity:** - Fewer disruptions to energy services due to climate shocks **Enhanced coping ability due to restorative capacity:** - Fewer days to restore energy services disrupted by climate shocks **Enhanced coping ability due to restorative-related transformative capacity:** - Fewer days to restore system-wide energy services disrupted after extreme events

Table 9 (continued): Collection of (more general) illustrative climate resilience indicators for the energy sector

	Climate-resilient infrastructure (generation, transmission, and distribution)
Output indicators	**Absorptive capacity:** - # of energy infrastructure design documents with sections that specifically address **robust** and **protected** infrastructure - Infrastructure investment documents documenting **protection, robustness,** and **diversification** **Absorptive-related transformative capacity:** - # of sections in renewable energy designs evidencing greater ability to absorb fluctuations **(robustness)** due to climate shocks - Documentation of interconnectivity-infrastructure that includes evidence on how **interconnection, diversification,** and **flexibility** are included in the system **Restorative capacity:** - # of energy infrastructure design documents with sections that specifically address **redundancies** and **reparability** of infrastructure - Infrastructure investment documents documenting **redundancies** and **easy reparability** after extreme weather event **Restorative-related transformative capacity:** - Documentation of interconnectivity infrastructure that includes evidence on how **interconnection, diversification, and flexibility** are included in the system
Outcome indicators	**Reduced losses due to absorptive capacity:** - Fewer days of energy service outages when a climate shock occurs (rural and urban areas) - Metric of lower infrastructure damage caused by climate shocks **Reduced losses due to absorptive-related transformative capacity:** - Fewer system-wide disruptions to energy services due to climate shocks **Enhanced coping ability due to restorative capacity:** - Fewer days to restore energy services disrupted by climate shocks - Fewer days to repair damaged infrastructure caused by climate shocks **Enhanced coping ability due to restorative-related transformative capacity:** - Fewer days to restore system-wide energy services disrupted after extreme events - Fewer days to repair damaged infrastructure caused by climate shocks

5.3 Fiscal policy and management

81. Fiscal instruments are crucial for adapting to climate change and building climate resilience. According to the World Bank report *Fiscal policies for development and climate action (2018),* preventive investments that anticipate the effects of climate change yield better economic outcomes than remedial actions responding to effects that have already occurred. Fiscal policies and management can contribute to building climate resilience by mobilizing and allocating resources to invest in adaptation, enhancing institutional capacity, building fiscal buffers and promoting insurance mechanisms. There are various measures that can be taken to reduce vulnerabilities in the sector and enhance climate resilience.

- Preparatory/planning activities: develop guidelines to include resilience criteria in the management of public investment programs; generate knowledge on impacts of and responses to climate change through fiscal policies (e.g. incentives, resource mobilization and optimal allocation); quantify and incorporate climate risks into mid-term fiscal frameworks and contingent risk analyses accompanying the budget; build climate-change considerations into the design, appraisal, and selection of all public investment projects; design rules/ mechanisms for public relief interventions and transfers; identify the use of environmental tax instruments; design and Implement environmental taxes that reduce use of fossil fuels and carbon emissions; use risk-identification models and systems that incorporate climatic shocks to understand/predict fiscal impacts; review public expenditures in the light of current and future vulnerability to climate change; ensure that benefits to greater resilience are accounted for when determining optimal budget allocation; enhance green and climate-resilient procurement practices and conduct training for procurement managers.

- Institutional/regulatory activities: develop methodologies and tools for tracking public expenditure on climate change to improve transparency and decision-making on budget allocation and to optimize public action in addressing the challenges imposed by climate change and environmental protection; implement or enhance risk-assessment and management systems for public investments; enhance fiscal incentives that efficiently increase private sector investment in climate resilient technologies, practices, infrastructure and services; design fiscal rules that help avoid pro-cyclical policies that would magnify climate risks and can provide the discipline to gradually increase investments in adaptation and climate resilience; define specific expenditure responsibilities with respect to climate-related damages and disasters and building climate resilience to sub-national and national governments; engage in regional collaboration to pool climate risks across countries (e.g., Caribbean Catastrophe Risk Insurance Facility); maintain fiscal space to respond to climate-related disasters; define institutional processes for verification and reporting of the public investment program's contribution to NDCs

- Technology adoption: e.g., increase the resilience of the technological infrastructure of tax and financial public management

- Climate-resilient infrastructure: ensure the climate resilience of the public sector and public investment projects; make preventive public investments in adaptation to address the gradual impacts of climate change and prepare the economy for extreme weather events

82. Considering relevant climate resilience elements in the design of fiscal policy and management projects will lower expected losses and increase coping ability.

83. The following table presents a group of illustrative indicators for climate resilience and a comparison with regular development indicators that do not consider climate resilience from projects approved at the IDB.

Table 10: From regular development indicators to climate resilience indicators in the sector of fiscal policy and management

Climate resilience opportunity	Project activity	Example of a related indicator that does not yet consider adaptation and climate resilience	Aspects of climate resilience that could be included	Illustrative example of a climate resilience indicator
Preparatory activities/ sector-wide planning activities	Risk assessment in public investment management systems	Intermediate output indicator: Incorporation of risk management within the life cycle of public investment projects	Integrate climate-related risks into the risk assessment processes of public investment management systems	Climate resilience intermediate output indicator: Documentation that disaster and climate change-related risks have been incorporated into the risk-management processes within the life cycle of public investment projects
	Identification, quantification, and reporting of public expenditure	Output indicator: Budget classification revised and updated	Consideration of absorptive elements **(protection, robustness)** and restorative elements **(options, recovery, redundancies)** in budget programs, activities and projectts	Climate resilience output indicator: Increase from X% to X% in public expenditures for adaptation-related activities
	Capacity building for public servants in topics related to the preparation, structuring, and monitoring of Public-Private Partnership (PPP) projects	Output indicator: # of public servants trained in PPPs	Addressing of absorptive elements **(protection, robustness)** and restorative elements **(options, recovery, redundancies)** in training in order to strengthen institutional capacities to manage climate risks in PPP investment projects	Climate resilience output indicator: - # of public servants trained in topics to ensure the climate resilience of PPP - # of climate resilience elements (e.g., **protection, robustness, options, recovery, redundancies**) covered in the PPP training of public servants
Institutional/ regulatory activities	Fiscal risk management	Output indicator: Incorporation of risk management within the medium-term fiscal framework	Consideration of the impact of disaster and climate change-related risks on fiscal risks and inclusion into the risk-management activities	Climate resilience output indicator: Documentation of disaster and climate change-related risks and responses within the medium-term fiscal framework to increase **preparedness, robustness, flexibility,** and **recovery**
	Risk-assessment processes for public investments	Output indicator: # of agencies that use methodologies to identify, prioritize, and mitigate risks in public investment projects	Integrate climate-related risks into the risk-assessment processes followed by public agencies	Climate resilience output indicators: - # of agencies that use methodologies to identify, prioritize, and mitigate risks, including climate-related risks, in public investment projects - % of public investment projects that have undergone a disaster and climate-change risk assessment
	Developing and implementing climate budget tagging	Intermediate output indicator: Country has adopted climate budget tagging Output indicator: Climate budget share has increased from X% to X% relative to the total budget	Ensure that climate budget for climate adaptation and resilience measures can be tagged	Climate resilience intermediate output indicator: Country has adopted climate budget tagging that allows for tagging climate adaptation/resilience budget Climate resilience output indicator: Climate adaptation/resilience budget share has increased from X% to X% relative to the total budget
	Developing and implementing green procurement norms	Intermediate output indicator: % of green public procurement over total public procurement	Ensure that public procurement norms also consider aspects related to climate resilience	Climate resilience intermediate output indicator: # of climate resilience elements (e.g., **preparedness, robustness, options**) considered in adopted green procurement norms Climate resilience output indicator: % of green and climate-resilient public procurement over total public procurement
	Operationalization of a risk management model	Intermediate output indicator: # of agencies that use the risk-management model to identify, prioritize, quantify, assign, and mitigate PPP project risks	Ensure that models use best available evidence **(knowledge, preparedness)** on climate change and include climate-related risks and impacts under different scenarios	Climate resilience intermediate output indicators: - # of agencies that screen PPP projects for climate-related risks **(preparedness, robustness)** - # of climate-related risks included into the risk management model for PPP projects (preparedness, robustness)

Table 10 (continued): From regular development indicators to climate resilience indicators in the sector of fiscal policy and management

Climate resilience opportunity	Project activity	Example of a related indicator that does not yet consider adaptation and climate resilience	Aspects of climate resilience that could be included	Illustrative example of a climate resilience indicator
Climate-related technologies	Implementation of an IT infrastructure in tax and public finance management systems	Output indicator: # of systems supported by new/enhanced IT infrastructure	Include climate-related risk analysis and adaptation measures in the design, construction/retrofit and operation of IT infrastructure, allowing greater **protection, robustness, redundancy,** and **integration/connectiveness**	Climate resilience output indicator: # of systems supported by new/enhanced IT infrastructure that is robust regarding climate shocks
	Adoption of technologies to reduce fiscal risks	Output indicator: # of technologies adopted that reduce fiscal risks	Include technologies, such as geographic information system (GIS)-based early warning systems that increase fiscal system preparedness to respond to climatic hazards	Climate resilience output indicator: # of technologies adopted that enhance fiscal system preparedness to respond to climatic hazards
Climate-resilient infrastructure	Preparation and structuring of PPP projects in priority sectors	Output indicator: Value of strategic PPP investments in priority sectors	Include specific climate resilience elements that designs of public infrastructure should include (e.g., **protection** and **robustness**)	Climate resilience output indicator: # of strategic PPP projects in priority sectors that reference **protection** and **robustness** regarding climate change in design documents
		Outcome indicator: Metrics of the benefits that the public infrastructure provides	Measure the reduced losses connected with the increased absorptive capacities of PPP projects	Climate resilience outcome indicator: Reduced damage to PPP investments due to climatic shocks

84. Below is a collection of additional indicators, some of them more general, organized by type of activity to illustrate the variety of climate resilience metrics and to inspire and guide the development of context- and project-specific indicators.

Table 11: Collection of (more general) illustrative climate resilience indicators for the sector of fiscal policy and management

	Preparatory activities/sector-wide planning activities that increase preparedness to promote adaptation and resilience to climate change
Intermediate output indicators	**Absorptive capacity:** - # of absorptive elements addressed in capacity-building materials **(learning/awareness)** on infrastructure design, investment, and management **(protected, robust)** - # of knowledge products **(learning/awareness)** that • incorporate the role of climatic risks in ensuring fiscal sustainability **(prepared, robust)** • evaluate fiscal policies to promote social inclusion, equity, and climate resilience **(prepared, robust)** • incorporate the role of climatic risks in efficient mobilization and allocation of resources **(protected, robust)** - # of absorptive elements incorporated into budget-allocation valuation processes **(prepared, protected, robust)** - # of absorptive elements addressed in public expenditure review documents **(prepared, protected, robust)** - # of indicators developed (learning/awareness) to measure fiscal impacts on vulnerability to climatic shocks (**robust** public service provision) - Documentation that disaster and climate change-related risks have been incorporated into the risk-management processes within the life cycle of public investment projects **Restorative capacity:** - # of restorative elements addressed in capacity-building materials on infrastructure design, investment, and management **(reparability/modularity, redundancies)** - # of knowledge products **(learning/awareness)** that • incorporate the role of climatic risks in ensuring fiscal sustainability **(options, integration/connectedness, reparability, redundancies)** • evaluate fiscal policies to promote social inclusion, equity, and climate resilience **(flexibility, integration/interconnectedness, recovery)** • incorporate the role of climatic risks in efficient mobilization and allocation of resources **(options, reparability, redundancies)** - # of restorative elements incorporated into budget-allocation valuation processes **(options, reparability, redundancies)** - # of restorative elements addressed in public expenditure review documents (**options** for **recovery, diversification**) - # of indicators developed (learning/awareness) to measure fiscal impacts on vulnerability to climatic shocks (**options** for **recovery, reparability/reconstruction**) - # of risk management mechanisms evaluated by tax system risk-identification models **(options, flexibility, diversification)**
Output indicators	**Absorptive-related capacity:** - # of infrastructure and service provision design documents with sections that specifically address **robust** and **protected** infrastructure (noting that actual investments likely to be undertaken by specific sectors) - Increase in budget allocated to **protected, robust** infrastructure - Increase from X% to X% in public expenditures for adaptation-related activities **Absorptive-related transformative capacity:** - # of public servants trained in topics to ensure the climate resilience of PPP - # of climate resilience elements (e.g., **protection, robustness, options, recovery, redundancies**) covered in the PPP training of public servants - Increase in value/share of budget allocated to investments in monitoring **(preparedness)** climatic conditions and in **robust** and **protected** infrastructure and service provision **Restorative-related capacity:** - # of infrastructure documents with sections that specifically address **redundancies, recovery of infrastructure** - Increase in budget allocated to increase restorative-related infrastructure **(redundancies, reparability)** **Restorative-related transformative capacity:** - Increase in value/share of budget allocated to investments to **integrate** response to climatic shocks, more timely **recovery,** and **redundancies**

Table 11 (continued): Collection of (more general) illustrative climate resilience indicators for the sector of fiscal policy and management

	Sector policy, legal, institutional, and regulatory activities that enhance climate resilience
Intermediate output indicators	**Absorptive-related capacity:** - # of sections in fiscal sustainability and financial risk management protocols identifying climate risks **(learning, preparedness)** - # of financial regulations adopted to facilitate access to international climate finance sources to fund **protected** and **robust** infrastructure - # of fiscal incentives adopted to spur increased private investment in **robust** infrastructure and operations **Absorptive-related transformative capacity:** - # of absorptive elements guiding system-wide budget allocation mechanisms **(preparedness, integration, robustness, protection)** - # of mechanisms within multi-level expenditure framework **(polycentricity, integration)** that address **robust** infrastructure and service provision - Country has adopted climate budget tagging that allows for tagging climate adaptation/resilience budget **Restorative-related capacity:** - # of sections in fiscal sustainability financial risk-management protocols documenting options for **responding** to climatic shocks, **reconstruction** - # of financial regulations designed to facilitate access to international climate finance sources to fund **redundancies, integration/interconnectedness,** and infrastructure designed to be rapidly **repaired** - # of fiscal incentives adopted to spur increased private investment in **redundancies** and **diversification** to respond to climatic shocks **Restorative-related transformative capacity:** - # of restorative elements guiding system-wide budget allocation mechanisms **(recovery, reparability, redundancies)** - # of mechanisms within multi-level expenditure framework **(polycentricity, integration)** that address **recovery** of infrastructure and service provision after a climate shock
Output indicators	**Absorptive-related capacity:** - # of financing agreements with international climate finance sources to fund **protected** and **robust** infrastructure - # of international climate finance sources accessed **(integration, diversification)** - # of private sector actors securing fiscal incentives to invest in absorptive resilience elements **(robustness and protection)** - # of absorptive elements addressed in fiscal policy mechanisms that increase climate resilience of poor and marginalized people **(robustness, protection)** **Absorptive-related transformative capacity:** - # of fiscal sustainability and financial risk-management mechanisms related to climatic shocks operationalized system-wide that increase **diversification** and **integration/coordination** - Increase in value/share of budget allocated to investments in monitoring **(preparedness)** climatic conditions and in **robust** and **protected** infrastructure and service provision - Performance metrics on **polycentric** and **integrated** multi-administrative expenditure systems that increase system **robustness** - Documentation of disaster and climate change-related risks and responses to increase preparedness and robustness within the medium-term fiscal framework - # of climate resilience elements (e.g., **preparedness, robustness**) considered in adopted green procurement norms **Restorative-related capacity:** - # of financing agreements with international climate finance sources to fund **redundancies, integration/ interconnectedness**, and infrastructure designed to be rapidly **repaired** - # of private sector actors securing fiscal incentives to invest in restorative resilience elements **(redundancies and diversi ication)** - # of restorative elements addressed in fiscal policy mechanisms that increase climate resilience of poor and marginalized people **(reparability, recovery)** **Restorative-related transformative capacity:** - # of fiscal sustainability and financial risk-management mechanisms related to climatic shocks operationalized system-wide that increase **diversi ication** and **integration/coordination** - Increase in value/share of budget allocated to investments to **integrate** response to climatic shocks, more timely **recovery,** and **redundancies** - Performance metrics on **polycentric** and **integrated** multi-administrative expenditure systems that increase system **recovery** - Documentation of disaster and climate change-related risks and responses to increase options and recovery within the medium-term fiscal framework - # of climate resilience elements (e.g., **options**) considered in adopted green procurement norms
Outcome indicators	**Absorptive-related transformative capacity:** - Lower negative impacts on metrics of fiscal sustainability due to climatic shocks - Reduced damage resulting from climatic shocks to public and private sector infrastructure due to higher investments from public budget allocation, international climate financing sources, and fiscal incentives - Reduced damage resulting from climatic shocks to public infrastructure due to multi-level governance expenditure system - Reduced damage resulting from climatic shocks to public infrastructure that primarily serves poor and marginalized communities due to multi-level governance expenditure system **Restorative-related transformative capacity:** - More rapid disbursement of recovery funds after a climatic shock - Fewer days to restore public service provision and private operations after climatic shocks due to higher investments from public budget allocation, international climate financing sources, and fiscal incentives - Reduction in public service disruptions resulting from climatic shocks to public infrastructure due to multi-level governance expenditure system - Reduction in public service disruptions in poor and marginalized communities resulting from climatic shocks to public infrastructure due to multi-level governance expenditure system

Table 11 (continued): Collection of (more general) illustrative climate resilience indicators for the sector of fiscal policy and management

Technology adoption and service provision	
Intermediate output indicators	**Restorative-related transformative capacity:** - # of risk-identification models for the tax system operationalized that use best available evidence on climate change to evaluate **options** to manage, **diversify**, and respond to climate risks
Output indicators	**Restorative capacity:** - # of systems supported by new/enhanced IT infrastructure that is **robust** regarding climate shocks **Restorative-related transformative capacity:** - # of mechanisms evaluated by tax system risk-identification models to address restorative elements in the tax system **(options, diversi ication, recovery)**
Outcome indicators	**Enhanced coping ability due to restorative capacity:** - Metrics of reduced variability of tax revenues due to climatic shocks - Less time to restore IT services and system functionality
Climate-resilient infrastructure	
Output indicators	**Absorptive capacity:** - # of infrastructure and service provision design documents with sections that specifically address **robust** and **protected** infrastructure (noting that actual investments likely to be undertaken by specific sectors) - Increase in budget allocated to **protected, robust** infrastructure - # of absorptive elements in infrastructure design documents **(robustness, protection)** financed by international climate finance sources - # of private sector actors securing fiscal incentives to invest in absorptive resilience elements **(robustness and protection)** **Restorative capacity:** - # of infrastructure documents with sections that specifically address **redundancies** and **recovery** of infrastructure - Increase in budget allocated to increase restorative-related infrastructure **(redundancies, reparability)** - # of restorative elements in infrastructure design documents **(redundancies, reparability)** financed by international climate finance sources
Outcome indicators	**Reduced losses due to absorptive capacity:** - Metric of lower infrastructure damages caused by climate shocks **Enhanced coping ability due to restorative capacity:** - Fewer days to repair damaged infrastructure after climatic shocks - Metrics of more rapid disbursement of recovery funds to repair infrastructure after climatic shocks

5.4 Housing and urban development

85. Cities, urban settlements, urban infrastructure, and transportation systems are highly vulnerable to climate change and natural disasters. Climate hazards, including higher temperatures, changing precipitation, and increasing frequency and severity of weather extremes, pose severe challenges, such as extreme heat, challenges in water management (e.g., flash floods or drying aquifers) as well as high vulnerability of underserved and/or informal neighborhoods located on hillsides, ravines, or riverbanks vulnerable to landslides and floods. There are various measures that can be taken to reduce vulnerabilities in the sector and enhance climate resilience,

- Preparatory: Development of knowledge documents and neighborhood and environmental plans that incorporate climate risk management, planning documents for public green spaces that apply adaptive urban planning (AUP) and/or nature-based solutions (NBS) approaches, mobility system plans that apply AUP/NBS approaches, collection and analysis of data to support the evidence base for developing climate-resilient policymaking.

- Institutional/regulatory: Improved communication and coordination within and between cities and municipalities as well as with the national government to respond to and manage emergencies due to climatic shocks, revision/adoption of building codes that increase climate resilience, revision/adoption of design standards for private and public spaces that apply AUP/NBS approaches, development of territorial arrangements to manage natural resources that apply AUP/NBS approaches.

- Infrastructure: Investment in climate-resilient infrastructure (urban neighborhood upgrading, rural housing stock, affordable housing, heritage sites) including consideration of green solutions to protect populations and critical city infrastructure vulnerable to climatic shocks and slow-onset stressors: urban riparian areas, permeable pavements, and bioswales that can reduce impacts of pluvial and riverine flooding in cities, green roofs, urban forests, and parks that contribute to urban flood mitigation while also reducing urban heat or targeted forestation and vegetation management that reduces landslide risk in urban areas near hillsides.

- Technology adoption: Promote adoption of early-warning system technology to help institutions coordinate emergency responses during critical events, generate and promote adoption of new construction-sector technologies that increase climate resilience through procurement and acquisition policies.

86. Considering relevant climate resilience elements in the design of housing and urban development projects will lower expected losses and increase coping ability. By reducing losses from extreme climate events, by facilitating shifts in urban design and service management to accommodate slower-moving climate changes, and by enhancing the ability to cope with weather shocks when they occur, climate resilience will contribute to the well-being of the urban population.

87. The following table presents a group of illustrative indicators for climate resilience and a comparison with regular development indicators that do not consider climate resilience from projects approved at the IDB.

Table 12: From regular development indicators to climate resilience indicators in the sector of housing and urban development

Climate resilience opportunity	Project activity	Example of a related indicator that does not yet consider adaptation and climate resilience	Aspects of climate resilience that could be included	Illustrative example of a climate resilience indicator
Preparatory activities/sector-wide planning activities	Urban neighborhoods improved	Output indicator: m2 of improved neighborhoods Outcome indicator: Reduced % of families in neighborhoods with low wellbeing/livability	Neighborhood and public spaces designed to be robust, to protect inhabitants, buildings, and heritage sites, and to increase ability to recover from climate shocks Improved design of neighborhoods and public spaces reduce expected damage due to floods, landslides, and high temperatures	Climate resilience output indicator: # of climate resilience elements addressed in neighborhood design documents **(robustness, protection, recovery)** Climate resilience outcome indicator: Reduced expected damage due to floods and landslides
Sector policy, legal, institutional, and regulatory activities	Develop operations and management plans for revitalized infrastructure	Output indicator: Operations and maintenance plan for revitalization works	Operations and maintenance plans integrate best available evidence on climate change **(learning)** to ensure revitalization works remain robust and protected over the long term	Climate resilience output indicator: # of climate resilience elements addressed in operations and maintenance plan documents **(learning, preparedness, robustness, protection, reparability)**
Climate-related technologies and services	Develop digital platforms for better coordination and linkage of services providers at national parks	Output indicator: # of digital platforms that are operational Outcome indicators: - Increased # of annual visitors - Hectares of land for which management effectiveness indicators show improved management of natural ecosystems	Digital platforms connect relevant stakeholders, share critical information **(learning)** increasing ability to prepare for climate shocks and integrate responses to those hazards Platforms reduce disruptions in service caused by climate shocks	Climate resilience output indicator: # of climate resilience elements **(learning, connectivity, preparedness, integrated responses)** addressed in the design documents of the platforms Managing effectiveness indicators showing reduced service disruptions from climate shocks
Climate-resilient infrastructure	Facades of historic buildings improved	Output indicator: m2 of improved facades Outcome indicator: Increase in value of properties in historic center according to property value index	Facades designed to be robust regarding climate hazards and to facilitate rapid repairs when necessitated by climate shocks Improved facades lower expected damages due to floods, landslides, and high temperature spikes	Climate resilience output indicator: # of resilience elements addressed in facade improvement documents (e.g., **robustness, reparability**) Climate resilience outcome indicator: Lower expected costs to repair facades due to floods, landslides, and high temperatures

88. Below is a collection of example indicators, some of them more general, organized by ype of activity to illustrate the variety of climate resilience metrics and to inspire and guide the development of context-and project-specific indicators.

Table 13: Collection of (more general) illustrative climate resilience indicators for the sector of housing and urban development

	Preparatory activities/sector-wide planning activities that increase preparedness to promote adaptation and resilience to climate change
Intermediate output indicators	**Absorptive capacity:** - # of absorptive elements in neighborhood/municipal/environmental/green spaces/mobility systems plans and housing regulations (**learning/awareness**, e.g., about **robustness and protection**) - # of reports with evidence on options for robust infrastructure designs (**learning/awareness** about **robustness**) **Restorative capacity:** - # of restorative elements in neighborhood/municipal/environmental/green spaces/mobility systems plans and housing regulations (**learning/awareness**, e.g., about **preparedness, reparability**, and **options** after climate shocks) - # of reports with evidence on options for recovery, including **redundancies, reparability (learning/awareness,** e.g., about **options** for recovery, including **redundancies** and **reparability**)
Output indicators	**Absorptive capacity:** - # of project activity/component design documents that increase **robustness** - # of policy documents that cite evidence on **robustness** and **protection** (**learning/awareness** about **robustness** and **protection**) - # of city planning documents and land-use zoning documents that address climatic conditions to increase **robustness** and **protection** **Restorative capacity:** - # of activity design documents that increase **reparability** - # of policy documents that cite evidence on **reparability** and **recovery options** (**learning/awareness** about **reparability** and **recovery options**), such as an emergency protocol in case of an extreme flood event (setting up shelters, providing electricity from alternative generators, etc.)
	Support of institutional/regulatory activities that increase preparedness to promote adaptation and resilience to climate change
Intermediate output indicators	**Absorptive capacity:** - # of building codes developed within the project that explicitly address **robustness, protection** - # of design standards developed within the project that explicitly address **robustness** and **protection** **Absorptive-related transformative capacity:** - # of institutional communication and **coordination** mechanisms identified to increase service provision that is **robust** regarding climatic shocks - # of territorial governance mechanisms identified that increase the **robustness** of the natural resource system **Restorative capacity:** - # of building codes developed within the project that explicitly address **reparability, modularity** - # of design standards developed within the project that explicitly address **reparability** and **redundancies** **Restorative-related transformative capacity:** - # of institutional communication and coordination mechanisms identified that **integrate/coordinate** responses to climatic shocks - # of territorial governance mechanisms identified that **integrate/coordinate** responses to climatic shocks

Table 13 (continued): Collection of (more general) illustrative climate resilience indicators for the sector of housing and urban development

	Support of institutional/regulatory activities that increase preparedness to promote adaptation and resilience to climate change
Output indicators	**Absorptive capacity:** - Metrics of institutional coordination actions/mechanisms operationalized to increase **robustness,** e.g., city cooperation center built and operational with operations documents detailing increased capacity to prepare for natural disasters through **learning** and **preparedness, integration/coordination** across government agencies - Metrics of **robustness-** and **protection**-related regulations implemented, e.g., # of climate resilience elements addressed in regulations (e.g., **learning, robustness, protection**) that ensure that housing units are constructed to be **robust** regarding floods and landslides and that structures built in irregular settlements **protect** people and infrastructure from damage due to climate shocks - Metrics of policies implemented that enhance **redundancies** to absorb climate shocks, e.g., to easily integrate redundancies in the infrastructure design of urban utility services - Design documents of buildings that adhere to climate resilience-related building codes and design standards, e.g., incorporating **robustness** and **protection** to ensure protection from natural disasters and increase the robustness of the infrastructure - Design documents of public spaces that adhere to climate resilience-related building codes and design standards, e.g., incorporating **robustness** and **protection** to ensure protection from natural disasters and increase robustness **Absorptive-related transformative capacity:** - # of institutional communication and **coordination** mechanisms operationalized to increase service provision, related, e.g., to transportation, cultural amenities, or recreational areas, that are **robust** regarding climatic shocks - # of territorial governance mechanisms operationalized to increase the **robustness** of the natural resource system **Restorative capacity:** - Metrics of institutional coordination actions/mechanisms operationalized to increase **preparedness** and **reparability** in response to extreme weather, e.g., city cooperation center built and operational with operations documents detailing increased capacity to respond to natural disasters through **learning** and **preparedness, integration/coordination** across government agencies, and improved disaster **response** and **repair** times - Metrics of **preparedness**- and **reparability**-related regulations implemented, e.g., # of climate resilience elements addressed in regulations (e.g., **learning, recovery, reparability, reconstruction**) that ensure that housing units and structures built in irregular settlements are constructed to be easily **reparable** and **reconstructed** when affected by climate shocks - Metrics of policies implemented that enhance **options** to ena ble rapid **recovery** and **repair**, e.g., to easily recover and repair infrastructure and ancillary equipment for urban utility services - Design documents of buildings that adhere to climate resilience/related building codes and design standards, e.g., incorporating reparability and options to recover to ensure cost-effective reparability and/or options to recover in the case of a climatic event - Design documents of public spaces that adhere to climate resilience-related building codes and design standards, e.g., incorporating **reparability** and **options to recover** to ensure cost-effective reparability and/or options to recover in the case of a climatic event **Restorative-related transformative capacity:** - # of institutional communication and coordination mechanisms operationalized to integrate/coordinate responses to climatic shocks - # of territorial governance mechanisms operationalized to integrate/coordinate responses to climatic shocks
	Adoption of climate-related technologies
Output indicator	**Absorptive capacity:** - # of absorptive elements **(robustness, protection**, etc.) incorporated into technology design documents - # of technologies adopted that enhance preparedness, protection, coordination, etc. (e.g., early-warning systems technology, wildfire danger rating system) **Restorative capacity:** - # of restorative elements **(reparability, redundancies,** etc.) incorporated in technology design documents - # of technologies adopted that enhance **coordination, redundancies, reparability, recovery,** etc. (e.g., early-warning system that helps institutions coordinate emergency response and recovery)
Outcome indicators	**Reduced losses due to absorptive capacity:** - Reduced damage to infrastructure built with new technologies - Reduced damage in urban areas due to technologies adopted that enhance preparedness, protection, etc. (e.g., early-warning systems technology that helps institutions prepare for critical events) **Enhanced coping ability due to restorative capacity:** - Fewer days needed to repair infrastructure built with new technologies - Fewer days needed to repair damages in urban areas due to technologies adopted that enhance coordination, redundancies, reparability, recovery, etc. (e.g., adoption of early-warning systems technology that helps institutions coordinate emergency responses during and after critical events)

Table 13(continued): Collection of (more general) illustrative climate resilience indicators for the sector of housing and urban development

	Provision of climate-resilient infrastructure
Output indicators	**Absorptive capacity:** - # of absorptive elements (**robust, protected,** etc.) incorporated in building/housing stock design documents to ensure protection from natural disasters and increase the robustness of the infrastructure - Increased expenditures on infrastructure to protect vulnerable populations and critical city infrastructure **Restorative capacity:** - # of restorative elements (**reparability, redundancies,** etc.) incorporated in building/housing stock design documents to ensure cost-effective reparability and/or redundancy of the infrastructure
Outcome indicators	**Reduced losses due to absorptive capacity:** - Reduced damage resulting from climate shocks and stressors - Reduced disruptions in value chains due to climate shocks and stressors - Fewer # of structures that are damaged or that collapse during an extreme event - Fewer people harmed during an extreme event **Enhanced coping ability due to restorative capacity:** - Fewer days to repair damages after climate shocks - Fewer days to restore value chain infrastructure after climate shocks and stressors

5.5 Transport

89. Transportation infrastructure and services for urban and inter-urban mobility, transport-related logistics infrastructure, and freight services are vulnerable to climate change-related hazards, including heavy rains and droughts, rising sea levels, heat and cold waves, and greater frequency and severity of hurricanes. In the absence of resilience-building activities and investments, infrastructure will be damaged from extreme climatic events and slow-onset impacts such as higher temperatures and sea-level rise; the maintenance of infrastructure will be costly and inefficient; travel will be interrupted from flooded roads being closed, and service disruptions in logistics systems after extreme events will incur additional costs.

90. There are various measures that can be taken to reduce vulnerabilities in the sector and enhance climate resilience.

- Preparatory (studies, database construction, planning documents, trainings, etc.): Assess climate vulnerability of transport infrastructure (e.g. via Blue Spot Analysis) and transport systems, support integrated planning frameworks that include climate change as a systems-related issue, use climatic data to analyze the interaction between extreme weather events and transportation use in order to assess vulnerabilities and identify potential priority investments/management/regulations for urban and interurban mobility systems, integrate weather data into logistics-monitoring systems to assess the impacts on the functioning of these systems and identify potential priority investments/management/regulations.

- Institutional/regulatory: Incorporate climate change in new regulations, guidelines, and operational frameworks, update national infrastructure guidelines to adopt technical standards that ensure climate-change resilience, support decision-making in uncertainty.

- Infrastructure, logistics, and transport-related technologies: Investment in climate-resilient infrastructure and NBS (such as managing forests to reduce landscape risk near roads, restoring coastal ecosystems such as reefs and tidal wetlands to reduce coastal flooding and erosion for coastal highways and railways, urban green infrastructure interventions to reduce risks of stormwater flooding that disrupts and damages urban transport systems), incorporation of the concept of resilience throughout the infrastructure life cycle (design, construction, operation, and maintenance), incorporation of principles for disaster risk management (including weather-related disasters) into logistics operations from the planning stage, use of resilient building materials, use of new technologies and digital connectivity to improve risk management (including weather risks and natural disasters), make use of mobile apps as response mechanisms to weather extremes and disasters.

91. Considering relevant climate resilience elements in the design of transport projects will reduce expected losses and increase coping ability. Urban and inter-urban mobility transportation systems that are better able to absorb weather shocks and slow-moving changes in climate conditions (greater transformative-absorptive capacity) and inter-urban mobility transportation systems that are better prepared and able to restore services affected by climatic conditions (greater transformative-restorative capacity) will positively impact improved logistics systems that lead to reduced losses due to climatic shocks and stressors (greater absorptive capacity) and are better prepared and able to restore services affected by climatic conditions (greater restorative capacity), transport sector regulations and institutions that increase the capacity of the sector to effectively absorb climatic shocks and stressors (greater transformative-absorptive capacity) and that enable system-wide restoration of services affected by climate shocks (greater transformative-restorative capacity), and the widespread adoption of innovative technologies that reduce losses to climatic shocks (greater absorptive capacity) and enable more swift recovery from climatic shocks (greater restorative capacity) will positively impact development within the sector and beyond.

92. The following table presents a group of illustrative indicators for climate resilience and a comparison with regular development indicators that do not consider climate resilience from projects approved at the IDB.

Table 14: From regular development indicators to climate resilience indicators in the transport sector

Climate resilience opportunity	Project activity	Example of a related indicator that does not yet consider adaptation and climate resilience	Aspects of climate resilience that could be included	Illustrative example of a climate resilience indicator
Preparatory activities/ sector-wide planning activities	Pre-investment study documents and dissemination materials	Intermediate output indicator: Technical feasibility analysis completed	Including climate resilience aspects at the design stage of an infrastructure project is cost effective. Elements that increase transport infrastructure's **reparability, redundancy, flexibility, robustness** will help build **absorptive** and **restorative capacities** and reduce its vulnerability to a climate shock.	Climate resilience intermediate output indicator: Technical feasibility assessment including a climate risk analysis completed (e.g., intensity-duration-frequency curves include climate-change considerations)
	Development of training modules covering resilient roadway designs and implementation of trainings	Output indicator: Training successfully implemented	Training on climate resilience for roadway infrastructure, management and maintenance will enhance **learning/awareness** of climate risks, will contribute to **preparedness** and lead to better **protected, more robust road.**	Climate resilience output indicator: # Resilience elements (e.g., future climate-change scenario evidence **(learning), robustness, protection, preparedness, integration/connectedness, and reparability)** addressed in training manual
Sector policy, legal, institutional, and regulatory activities	Development of a national transport framework	Output indicator: National transport framework developed	Ensure that the national transport framework addresses relevant aspects related to **absorptive** and **restorative capacities**	Climate resilience output indicator: The national transport framework addresses system **redundancies**, the ability to **absorb** climate shocks, and mobility **options** after climatic shocks to facilitate a rapid **recovery**
Climate-related technologies and climate-resilient transport and logistics systems	Use of technology for road safety	Output Indicator: Km of roads refurbished	High air-void content in permeable asphalt enables rainwater infiltration, while providing the necessary bearing capacity and durability. The use of this material will contribute to increasing **absorptive capacity** and will allow road to better handle excess water coming from a climatic shock, also enhancing **integration** and **connectivity**, as numbers of days out of service could be reduced.	Climate resilience output indicator: # of km of road refurbished with permeable asphalt pavement in areas exposed to flooding and extreme rainfall
Climate-resilient transport and logistics infrastructure	Improvement of provincial roads	Output indicator: Km of provincial roads improved	Road sections could be improved to protect from climate shocks. This can be done by using new materials or changing the design parameters, contributing to the **robustness** of the network, roads could also be built to be **easily repaired** and to increase their **flexibility. Redundancy** could also be considered as part of the improvements. These improvements will increase **absorptive** and **restorative capacities.**	Climate resilience output indicator: # of km of provincial roads that are climate-resilient
	Public transport infrastructure, metro	Outcome Indicator: Improved quality of public transportation service	The quality of public transportation service can be improved by including measures to make it climate-resilient. These measures include the use of new materials or elements in the design that enhance **reparability, connectedness, flexibility**, and **redundancy**	Climate resilience outcome indicator: Lower expected repair expenses from damages caused by climate shocks Reduction in time to restore services after climate shocks

93. Below is a collection of example indicators, some of them more general, organized by type of activity to illustrate the variety of climate resilience metrics and to inspire and guide the development of context- and project-specific indicators.

Table 15: Collection of (more general) illustrative climate resilience indicators for the transport sector

	Preparatory activities/sector-wide planning activities (e.g., transport-related database platforms, planning documents and pilot-testing) that increase preparedness to promote adaptation and resilience to climate change
Intermediate output indicators	**Absorptive capacity:** - # of climatic data sources integrated in data platforms (enhances the performance of transport services **(learning)**, increases the capacity to be **prepared** for climatic shocks and stressors and to assess system **robustness**) - # of absorptive resilience elements addressed in planning documents - # of absorptive resilience elements addressed in new technologies - # of technologies pilot-tested that increase **robustness, connectedness,** and provide **redundancies** - # of climate-related datasets merged into transport-sector databases (enhances **learning, preparedness,** and **complex adaptive thinking** related to absorptive capacity) **Absorptive-related transformative capacity:** - # of stakeholders contributing inputs to transport management plan document (enhances **integrated, polycentric governance, learning,** and **preparedness** in line with the stakeholders' needs) - # of sections in transport management plan document that address climatic conditions and risks (**learning/awareness** about **preparedness**) **Restorative capacity:** - # of climatic data sources integrated in data platforms (enhances the capacity to be **prepared** for climatic shocks and stressors and to **recover** from climatic shocks) - # of restorative resilience elements addressed in planning document - # of restorative resilience elements addressed in new technologies - # of technologies pilot-tested that increase **connectedness, lexibility** to respond to climate shocks - # of climate-related datasets merged into transport sector databases (enhances **learning, preparedness**, and **complex adaptive thinking** related to restorative capacity) **Restorative-related transformative capacity:** - # of stakeholders contributing inputs to transport management plan document (enhances **integrated, polycentric governance** and **learning**) - # of sections in transport management plan document that address **connectedness, lexibility,** and **options** and ensure access (in particular of marginalized populations) at all times, including during and after climatic shocks
Output indicators	**Absorptive capacity:** - # of analyses generating evidence on absorptive resilience elements (climate-related **learning/awareness,** potential contribution to **complex adaptive thinking** in future planning) - # of operational mechanisms that ensure that transport service/logistics systems are **robust** regarding climate events **Restorative capacity:** - # of analyses generating evidence on restorative resilience elements (climate-related **learning/awareness,** potential contribution to **complex adaptive thinking** in future planning) - # of operational mechanisms to improve **recovery** time of transports/logistics services after a climatic event - # of analyses generating evidence on improving **recovery** and **reconstruction** capacity of transport and logistics infrastructure and systems (**learning/awareness** about **recovery** and **reconstruction**, potential contribution to **complex adaptive thinking)** - # of analyses generating evidence identifying actions for **robust** logistics systems/service provision (**learning/awareness** about **robustness**, potential contribution to **complex adaptive thinking**) **Restorative-related transformative capacity:** - # of operational mechanisms to implement **recovery**- and **repair**-related activities in transport management plans

Table 15 (continued): Collection of (more general) illustrative climate resilience indicators for the transport sector

	Support of sector policy, legal, institutional, and regulatory activities (e.g., transport-related coordination mechanisms, new/revised regulations, and policy documents) that increase preparedness to promote adaptation and resilience to climate change
Intermediate output indicators	**Absorptive capacity:** - # of mechanisms included in institutional guidelines to increase **coordination** across functions and system **robustness** to current and future climatic conditions - # of absorptive resilience elements addressed in new/revised regulations, e.g., regulations addressing system **robustness** (this also enhances **learning**) - # of absorptive resilience elements addressed in transport/logistics policy documents, e.g., system **protection** and **robustness**, to ensure that transport/logistics systems are protected and robust - # of regulations that incorporate or are based, in part, on analyses of current and future climatic conditions **(learning)** to enhance transport system **robustness** - # sections in institutional guidelines that consider system **robustness** regarding current and future climatic conditions - # of mechanisms in national and regional transport frameworks to enhance **coordinated** responses to climatic shocks - # of sections of national and regional transport frameworks addressing system **redundancies** and the ability to absorb climate shocks **Absorptive-related transformative capacity:** - # of sections in transport logistics systems policy document that are based on an **integrated** perspective of system functions, including the consideration of future climatic changes in logistic-system functioning to enhance **preparedness** and ensure **protected** and **robust** logistics systems (policies that facilitate intra- and inter-institutional collaboration will also enhance **connectedness** and **polycentric governance**) **Restorative capacity:** - # of mechanisms included in institutional guidelines to increase **coordination** across functions to increase system **reparability** in the light of current and future climatic conditions - # of restorative resilience elements addressed in new/revised regulations, e.g., regulations addressing responses to climate shocks **(preparedness, reparability),** thereby facilitating system-wide restoration of services affected by climate shocks - # of regulations that incorporate or are based, in part, on analyses of current and future climatic conditions **(learning)** and transport system reparability - # of restorative resilience elements addressed in policy document - # of sections in institutional guideline addressing system **reparability** in light of current and future climatic conditions, thereby facilitating system-wide restoration of services affected by climate shocks - # of mechanisms in national and regional transport frameworks to enhance **coordinated** responses to climatic shocks, potentially including alternative **options** or system **redundancies** to facilitate system-wide restoration of services affected by climate shocks - # of sections of national and regional transport frameworks addressing **options** after climatic shocks to facilitate a rapid **recovery** **Restorative-related transformative capacity:** - # of sections in transport logistics policy document that are based on an integrated perspective of system functions, including the consideration of mechanisms to restore services after a climatic event to enhance **preparedness** and ensure the **recovery** of logistics systems (policies that facilitate intra- and inter-institutional collaboration will also enhance **connectedness** and **polycentric governance)**
Output indicators	**Absorptive capacity:** - Metrics of institutional coordination actions/mechanisms operationalized to increase **robustness,** e.g., cooperation office established and operational with operations documents detailing increased capacity to prepare for natural disasters through learning and preparedness, integration/coordination across government agencies - Metrics of **robustness**-related regulations implemented, e.g., # of climate resilience elements addressed in regulations (e.g., **learning, robustness, protection**) that ensure that transport infrastructure is constructed to be robust regarding floods and landslides and that infrastructure built in vulnerable areas can protect people from damage due to climate shocks - Metrics of policies implemented that enhance **redundancies** to absorb climate shocks - Metrics of institutional coordination actions/mechanisms operationalized to increase **robustness**, e.g., to easily integrate redundancies in the transport infrastructure design **Restorative capacity:** - Metrics of institutional coordination actions/mechanisms operationalized to increase **preparedness** and **reparability** in response to extreme weather, e.g., cooperation office established and operational with operations documents detailing increased capacity to respond to natural disasters through **learning** and **preparedness, integration/coordination** across government agencies, and improved disaster **response** and **repair** times - Metrics of **preparedness**- and **reparability**-related regulations implemented **(learning, recovery, reparability, reconstruction)**, e.g., to ensure that infrastructure built in vulnerable areas is constructed to be easily **reparable** and **reconstructed** when affected by climate shocks - Metrics of policies implemented that enhance **options** to enable rapid recovery and **repair**, e.g., to easily recover and repair transport infrastructure and ancillary equipment **Restorative-related transformative capacity:** - Documentation of ability to coordinate (integrate) agency actions to increase flexibility to recover from climatic shocks

Table 15 (continued): Collection of (more general) illustrative climate resilience indicators for the transport sector

Climate-related technologies and climate-resilient transport and logistics systems	
Output indicators	**Absorptive capacity:** - # of operational mechanisms to ensure **protection** and **robustness** of logistics systems regarding climatic events and stressors - # of technologies related to transport/logistics services and systems that have been adopted by people, firms, government agencies and that increase **robustness, connectedness**, and provide **redundancies** **Absorptive-related transformative capacity:** - # of sector-wide operational mechanisms to ensure that the transport service system is **robust** regarding climatic events - # of sections in sectoral rehabilitation/maintenance documents integrating climate considerations to increase the **preparedness** and **robustness** of urban and inter-urban transportation systems **Restorative capacity:** - # of operational mechanisms that facilitate the **reparability** of logistics services and ensure **redundancies** to restore logistics services after a climatic event - # of technologies related to transport/logistics services and systems that have been adopted by people, firms, government agencies and that improve **connectedness,** incorporate **redundancies**, and provide **flexibility** in transportation **options** in response to climatic shocks and stressors, and that enable swifter **recovery** **Restorative-related transformative capacity:** - # of sections in rehabilitation/maintenance documents integrating climate considerations to reduce time/expenses for repairs of urban and inter-urban transportation systems (enhances **preparedness, reparability, reconstruction,** and **recovery)**
Outcome indicators	**Reduced losses due to absorptive capacity:** - Reduced damage to transport/logistics systems caused by climatic events **Reduced losses due to absorptive-related transformative capacity:** - Fewer disruptions to transport/logistics systems due to climatic events **Enhanced coping ability due to restorative capacity:** - Reduced # of days to restore transport/logistics systems after climatic events **Enhanced coping ability due to restorative-related transformative capacity:** - Reduced # of days to restore transport/logistics systems after climatic events
Climate-resilient transport and logistics infrastructure	
Output indicators	**Absorptive capacity:** - # of absorptive resilience elements addressed in design documents of transport infrastructure to ensure **protection** from natural disasters and increase the **robustness** of the infrastructure - Documentation that intercity transportation network coverage (expansion) is robust regarding climatic shock to ensure **protection** from natural disasters and increase the **robustness** of the infrastructure **Absorptive-related transformative capacity:** - # of sections in system- or sector-wide transport/logistics infrastructure design documents documenting **robustness**, and **protection** against climatic shocks **Restorative capacity:** - Greater coverage of intercity transport networks (increases **flexibility** and **options** to respond to climatic shocks to a wider range of citizens and first-responders) - # of restorative resilience elements addressed in design documents of logistics/transportation infrastructure to ensure easy **reparability,** incorporate **redundancies**, and offer multimodalities that increase the diversity of transport **options** and **flexibility** to respond to climatic shocks - Documentation of intercity transportation network coverage (expansion) that facilitates repair and/or **redundancy** within the networks in response to climatic shock **Restorative-related transformative capacity:** - # of sections in system- or sector-wide transport/logistics infrastructure design documents documenting **reparability** and **redundant** components that will facilitate the restoration of services after climatic shocks

Table 15 (continued): Collection of (more general) illustrative climate resilience indicators for the transport sector

	Climate-resilient transport and logistics infrastructure
Outcome indicators	**Reduced losses due to absorptive capacity:** - Reduced damage caused by climatic events - Increase in market access during a climate shock **Reduced losses due to absorptive-related transformative capacity:** - Reduced costs to repair infrastructure and connections damaged by climatic shocks **Enhanced coping ability due to restorative capacity:** - Reduced # of days to restore transport/logistics services after climatic events - Reduced # of days to restore market access after a climate shock **Enhanced coping ability due to restorative-related transformative capacity:** - Reduced # of days to repair transport/logistics infrastructure and connections damaged by climatic shocks

5.6 Water and sanitation

94..At a general level, water security is understood as the existence of an acceptable level of water with an acceptable level of risk that allows the sector to satisfy various uses, to conserve water quality, and to take into consideration climate-change issues in the planning of infrastructure, flow management, and risk management for natural disasters. In particular, there is the need to understand climate-change impacts to ensure sustainability and continuity of potable water distribution. Climate hazards for water systems include, among others, higher extreme temperatures and increases/changes in patterns of frequency and intensity of rainfall, such as (i) torrential rainfall and floods and (ii) droughts. In connection with these, some of the more relevant impacts of climate change include: (i) sea-level rise in coastal zones, generating saline intrusion into aquifers, (ii) rapid glacial retreat, (iii) increase in water contamination, which lowers water quality and compromises its use, and (iv) losses and damage to lives, public infrastructure and private property, agricultural production, and business activities, due to torrential rainfall and floods. More specifically, (a) flood impacts storm and sanitary drainage (b) flood/excessive rainfall impacts siltation of dams and water networks and structural damage in water distribution systems, (v) greater damage in fast-growing, unplanned urban areas exposed to weather shocks, and (vi) increased environ-mental degradation and reduction in environmental services, including ecosystem services, exacerbated in areas with lack of adequate governance (e.g., climate change could be seen as a multiplier of the effects of environmental degradation of water sources).

95. There are various measures that can be taken to reduce vulnerabilities in the sector and enhance climate resilience.

- In regions characterized by prolonged droughts: (i) finance and facilitate systems to recycle water, (ii) increase water storage capacity, (iii) diversify options for water supply and expand current sources, (iv) design integrated drought monitoring system, (v) put in place a water-efficiency management plan and practice water conservation and demand management, (vi) strengthen actions to conserve ecosystems' services, especially those related to capturing and regulating water, and (vii) implement a watershed management plan with clear actions to promote the sustainable use of water resources, including fire management plans.
- Monitor operational capabilities: (i) conduct stress testing on biological wastewater treatment systems to assess tolerance to heat, (ii) manage reservoir water quality, (iii) monitor and inspect the integrity of existing infrastructure, and (iv) monitor vegetation changes in watersheds.
- Conjunctive use of water, which involves the coordinated, optimal use of both surface and groundwater, both intra- and-inter-annually. Aquifer storage and recovery could be considered, for example a type of conjunctive use.
- Continuous learning to understand implications of future scenarios for water stress across relevant sectors and systems, development of analytical tools for decision-making under deep uncertainty, studies to characterize climate risks and climate-change impacts, project – and infrastructure – designs that incorporate best available evidence on current and future hydro-meteorological variables, research to identify effective adaptation options, use of

modeling tools such as *HydroBID*[29] and Hydro-Flood to identify adaptation strategies, given particular climate scenarios.

- For those areas in which water quality is an issue and there is history of eutrophication events, wastewater treatment could be considered an adaptation measure. Higher sustained temperatures during the summer and high concentrations of phosphorus and nitrogen in the water could increase the risk of cyanobacteria blooms, negatively affecting water quality. Hence, removing phosphorus from the water as part of the water treatment process could help reduce the vulnerability of water users to these types of phenomena. In this case, climate change can be seen as a multiplier, increasing changing climate patterns and greater frequency of extreme events that affect water contamination.
- Infrastructure that is resilient to climate change, with designs based on best available evidence on which to model future climate-change scenarios, including building flood barriers to protect infrastructure and relocating facilities located in coastal or riverine areas to higher elevations.
- Sustainable IWRM, both infrastructure and governance/regulations, incorporating both the potential impacts of weather shocks and changing climate and the protection of ecosystem services in watersheds to ensure quality water supply.
- Design and build reservoirs and increase protection of upstream eco-system services to maintain quality water availability – or at least minimize reduced availability and/or discontinuity in service – in the event of droughts.
- Design and build embankments to protect against water surge and incorporate best available information on current and future climate-change scenarios into regulation of dams to prevent floods.
- Promote practices associated with sustainable use of groundwater to reduce probability of saline intrusion and/or install low-head dam.
- Early warning systems, climate-change monitoring systems.
- Develop contingency plans and energy management plans for key facilities and establish mutual aid agreements with neighbor utilities. For infrastructure located in coastal areas, develop coastal restoration plans.
- Institutional strengthening to build adaptive capacity, including ability to (i) carry out climate risk assessments, (ii) develop models to understand potential water quality changes, (iii) use hydrologic models to project runoff and future water supply, (iv) model inflow/infiltration in sewer systems, (v) develop models to understand potential water-quality changes, and (vi) conduct sea-level rise and storm-surge modeling.
- Secure financing for watershed management, including climate resilience activities; water fund mechanisms used for building climate resilience.
- Access to new and additional concessional international climate change adaptation financing and/or any other type of financial instrument to minimize financial impacts associated to climate and disaster risks, such as bonds, guarantees, and insurance, among others.

96. The following table presents a group of illustrative indicators for climate resilience and a comparison with regular development indicators that do not consider climate resilience from projects approved at the IDB.

[29] *HydroBID* is an integrated and quantitative system to simulate hydrology and water resources management in the LAC region, for scenarios of change (e.g., climate, land use, population) which allows for evaluating the quantity and quality of water, infrastructure needs, and the design of strategies and adaptive projects in response to these changes.

Table 16: From regular development indicators to climate resilience indicators in the sector of water and sanitation

Climate resilience opportunity	Project activity	Example of a related indicator that does not yet consider adaptation and climate resilience	Aspects of climate resilience that could be included	Illustrative example of a climate resilience indicator
Preparatory activities/sector-wide planning activities	Design of urban macro-drainage	Output indicator: Km of macro drainage designed Outcome indicator: Lower # of households at risk of flooding	Climate resilience should be incorporated as far upstream in project preparation as possible; a climate-resilient drainage system will have to be **lexible**, introduce **redundancy elements** in its design to facilitate **preparedness** and the **connectivity** of the overall system. These elements will help the system build **absorptive** and **restorative capacities.**	Climate resilience output indicator: Km of Sustainable Drainage Systems (SDS[30]) designed Climate resilience outcome indicator: Lower # of households at risk of flooding exacerbated by climate change
	Strengthen institutional capacity in terms of flood management and control	Output indicator: Monitoring and early warning systems deployed	Capacity-building materials on using monitoring and early warning system outputs **increase learning**, potentially **increase integration/connectedness, preparedness,** and **recovery** within watershed, contributing to increase both **absorptive** and **restorative capacities.**	Climate resilience output indicator: Guidelines/training/learning manuals for using monitoring and early-warning systems
Sector policy, legal, institutional, and regulatory activities	Planning of investments in water, sanitation, and storm drainage and establishment of policy guidelines to ensure their sustainability	Output Indicator: # of guidelines formulated for the national storm drainage strategy for cities with populations over 10,000	Guidelines and sector diagnostic assessments are very important tools to include specific criteria for climate resilience and could effectively contribute to **integrate/coordinate actions across multiple cities (polycentric governance)** on how to improve the design of water and sanitation infrastructure against climate shocks and stressors.	Climate resilience output indicator: # of guidelines formulated for the national storm drainage strategy for cities with populations over 10,000 that include climate resilience criteria
Climate-related technologies and service provision	Studies to ensure adequate operation/maintenance & sustainability of structural investments	Intermediate output Indicator Diagnostic assessments, action plans, final designs completed	Studies that explicitly include best available evidence on climate-change impacts on system **robustness, protection**, and potentially **recovery and reparability.** This will contribute to building system's **absorptive** and **restorative capacities.**	Climate resilience output indicator: Assessments, plans, and designs developed that explicitly address climate resilience criteria
	Monitoring and early warning systems in watersheds	Outcome indicator: Reduced expected economic damage	Monitoring and early-warning systems increase **absorptive capacity** through greater preparedness leading to greater **ability to reduce losses** to lives, private property, and public infrastructure, and greater **restorative capacity** by enabling **more timely response and recovery** leading to **reduced losses** after an extreme event.	Climate resilience outcome indicator: Reduced expected economic damage caused by climate shocks (e.g., drought/ flooding/ heat wave) Fewer days where infrastructure is not in operation

Table 16 (continued): From regular development indicators to climate resilience indicators in the sector of water and sanitation

Climate resilience opportunity	Project activity	Example of a related indicator that does not yet consider adaptation and climate resilience	Aspects of climate resilience that could be included	Illustrative example of a climate resilience indicator
Climate-resilient infrastructure for water and sanitation	Infrastructure for drainage and flood control in urban areas	Output indicator: Kms of channels constructed in *San Juan* river Output indicator: Regulating dam for *San Jose* creek constructed	Greater **absorptive capacity** from improved channels **reduces losses** to lives, private property, and public infrastructure, **reduces** business **disruptions**. Bridge/floodgate improvements increase **absorptive capacity**, leading to extended reliability, reduced **losses** to lives, private property, and public infrastructure, **reduced** business **disruptions.**	Climate resilience output indicators: Channels constructed with enhanced climate resilience in *San Juan* river Regulating dam with enhanced climate resilience for *San Jose* creek constructed *Climate-resilient means that the infrastructure withstands and continues to provide service when exposed to a climate shock (e.g., 100-year storm) for example, because of an enhanced design that uses frequency analysis incorporating climate-change projections or because its operation factors in contingency plans for climate shocks.
	Coastal or riverine ecosystems restoration/protection activities	Outcome indicator: Coastline where coastal risk is reduced based on protection provided by natural habitat	Coastal ecosystems restoration increases **transformative absorptive capacity**, leading to **reduction of losses** to lives, private property, business revenue, and public infrastructure from climate shocks.	Climate resilience outcome indicator: Reduced damage to property and assets for beneficiaries near restored coastal ecosystems when exposed to a climate shock (e.g., 100-year storm)
	Wastewater infrastructure	Output indicator: First module of sewage treatment plant operating to technical design specifications Outcome indicator: Households with sewer connections	Improved sewer system increases **absorptive capacity** through infrastructure that is **robust** regarding climate shocks, leading to **lower expected infrastructure damage, greater continuity in service** provision to households, and **higher water quality** during and following extreme hydro-climatic shocks.	Climate resilience output indicator: First module of sewage treatment plant operating to technical designs specifications that include climate-change considerations (e.g., flood-protection infrastructure) Climate resilience outcome indicators: Reduced expected infrastructure damage Fewer days that sewerage treated does not comply with discharge standards due to a climate shock (e.g., 50-year storm) Lower measures of biochemical oxygen demand under extreme weather events

97. Below is a collection of example indicators, some of them more general, organized by type of activity to illustrate the variety of climate resilience metrics and to inspire and guide the development of context- and project-specific indicators.

Table 17: Collection of (more general) illustrative climate resilience indicators for the sector of water and sanitation

Preparatory activities/sector-wide planning activities that increase preparedness to promote adaptation and resilience to climate change	
Intermediate output indicators	**Absorptive capacity:** - # of HydroBID/HydroFlood report sections on options for increasing **robustness** and **protection** - # of absorptive-related resilience elements **(learning, preparedness, robustness, complex-adaptive systems thinking)** addressed in knowledge products or other operational documents such as manuals or plans - # of technical assistance documents covering design of **robust** and **protected** infrastructure for water supply and sanitation - Hydro-meteorological data platform established and # of analyses disseminated that increase **learning** and enable governments and people to **prepare** for climate shocks and stressors by investing in **robust** and **protected** infrastructure - Data/monitoring system established to enable analyses of robustness and **protection** of infrastructure designs - # of assessments of impact of climate shock on service providers' **robustness** and **protection** performance - # of sections in pilot project's design documents that address **preparedness, protection**, and **robustness** **Absorptive-related transformative capacity:** - # of system-wide IWRM plans with sections addressing **robust** and **protected** investment proposals using knowledge generated from hydro-meteorological data, monitoring output, and technical assistance **Restorative capacity:** - # of restorative-related resilience elements **(reparability, recovery, redundancies)** addressed in knowledge products - # of technical assistance documents covering design of **redundant** and **easily reparable** infrastructure for water supply and sanitation - Hydro-meteorological data platform and # of analyses disseminated that increase **learning** and enable governments and people to **prepare** for climate shocks and stressors by increasing ability to **repair** and **recover** - Share of population signed up to receive weather alerts (**preparedness** to **respond** to shocks) - Data/monitoring system established to enable analyses of **preparedness** and **recovery** - # of assessments of impact of climate shock on service providers' **recovery** performance - # of sections in pilot project's design documents that address **flexibility, options, reparability, recovery** **Restorative-related transformative capacity:** - # of system-wide IWRM plans with sections addressing system-wide **redundancies, recovery** capacity, **options** for recovery, and **reparability** of investments using knowledge generated from hydro-meteorological data, monitoring output, and technical assistance - # contingency plans developed that address **preparedness, response options,** and **recovery**
Output indicators	**Absorptive capacity:** - # of water-related investment design documents with sections (e.g. materials, siting, construction methods) specifically addressing **protection** and **robustness** (based on knowledge product intermediate outputs (HydroBID modeling outputs, research studies, technical assistance, hydro-meteorological data analyses)) **Absorptive-related transformative capacity:** - # of investments from IWRM plans implemented that specifically address **robustness** and **protection** from a climate shock (e.g., drought, flood, high-velocity winds) **Restorative capacity:** - # of water-related investment design, with sections (e.g., materials, siting, construction methods) specifically addressing **redundancies** and **reparability** (based on intermediate outputs of knowledge products (HydroBID modeling outputs, research studies, technical assistance, hydro-meteorological data analyses)) **Restorative-related transformative capacity:** - # of investments from IWRM plans implemented that specifically address **redundancies**, and promote **recovery** capacity and **reparability** - # of digital platforms operationalized that helps institutions **coordinate** emergency response and **recovery** - # of contingency plans operationalized that address **preparedness**, **response options,** and **recovery**

[30] A SDS not only helps in preventing floods but also improves water quality and can enhance the physical environment and wildlife in urban areas. It includes the following elements: inlet control, infiltration devices, vegetated surfaces, permeable paving, filter drains, infiltration basins, detention and retention ponds, and constructed wetlands.

Table 17 (continued): Collection of (more general) illustrative climate resilience indicators for the sector of water and sanitation

	Sector policy, legal, institutional, and regulatory activities that enhance climate resilience (e.g., water and sanitation sector governance is strengthened by the incorporation of climate resilience considerations)
Intermediate output indicators	**Absorptive capacity:** - # of knowledge products with sections on **preparedness, protection** and **robustness** - # of technological assistance documents with sections on **integration/coordination** amongst multiple sectors **(polycentric governance)** to address **protection** of water infrastructure - # of public utility companies that continually collect and update climate information to determine retrofitting needs, e.g., of the drainage system **(managing slow variables and feedback)** **Absorptive-related transformative capacity:** - # of water sector-related framework documents with sections on **preparedness** and **robustness**, and mechanisms to **integrate/coordinate** actions to increase absorptive capacity across multiple sectors **(polycentric governance)** - # of public policy reforms adopted with sections on **robustness** and **protection** - # of mechanisms established for the management of public utility companies to continually collect and update climate information to determine retrofitting needs, e.g., of drainage systems **(managing slow variables and feedback)** **Restorative capacity:** - # of knowledge products with sections on **reparability, flexibility/redundancies**, and **recovery** - # of technological assistance documents with sections on **integration/coordination** amongst multiple sectors **(polycentric governance)** to address **repair** of water infrastructure damaged by climate shock or stressors **Restorative-related transformative capacity:** - # of water sector-related framework documents with sections on **reparability, redundancies**, and **recovery** options, and mechanisms to **integrate/coordinate** actions to increase restorative capacity across multiple sectors **(polycentric governance)** - # of public policy reforms adopted with sections on **reparability, flexibility/redundancies**, and **recovery**
Output indicators	**Absorptive capacity:** - # of water infrastructure and operations mechanism design documents with sections on **preparedness, protection,** and **robustness** based on knowledge products **Absorptive-related transformative capacity:** - # of public policy reform processes implemented that address **robust** and **protected** water infrastructure - # of mechanisms operationalized to **integrate/coordinate** actions across multiple sectors **(polycentric governance)** to address **protection** of water infrastructure (e.g., coordination mechanism in place between water/wastewater utilities and a local network of services such as law enforcement, emergency management, and fire and hazardous materials services) **Restorative capacity:** - # of guidelines for developing contingency plans that enhance water systems' **reparability, flexibility/redundancies**, and **recovery** **Restorative-related transformative capacity:** - # of public policy processes implemented that address **reparability, flexibility/redundancies,** and **recovery** - # of mechanisms operationalized to **integrate/coordinate** actions across multiple sectors **(polycentric governance)** to address rapid repair of water infrastructure damaged by climate shocks and stressors

Table 17 (continued): Collection of (more general) illustrative climate resilience indicators for the sector of water and sanitation

Climate-resilient technologies and service provision (infrastructure operation)	
Output indicators	**Absorptive capacity:** - # of water and sanitation operational mechanisms financed that increase **robustness** of service provision - # of technologies adopted and operationalized to increase **preparedness, robustness**, and **coordination/integration** of service provision **Absorptive-related transformative capacity:** - # of multi-sectoral coordination mechanisms implemented system-wide to increase system's **robustness** regarding climate shocks and stressors (e.g., watersheds-level coordination mechanism to develop and implement common strategies for managing shared water resources) - # of state-of-the-art technologies adopted systemwide to increase system's **robustness** regarding climate shocks and stressors **Restorative capacity:** - # of water- and sanitation-related operational mechanisms implemented that increase **recovery** of service provision - # of technologies adoptezd and operationalized to increase **redundancies, flexibility**, and options to **recover** **Restorative-related transformative capacity:** - # of multi-sectoral coordination mechanisms implemented system-wide to increase system's **flexibility** to **respond** and **restore** service outages caused by climate shocks and stressors (e.g., digital coordination platform in place between water/wastewater utilities and a local network of services such as law enforcement, emergency management, fire, and hazardous materials services) - # of state-of-the-art technologies adopted systemwide to **restore** service outages caused by climate shocks and stressors
Outcome indicators	**Reduced losses due to absorptive capacity:** - Fewer days of water service outages when a climate shock such as a 50-year storm occurs (rural and urban areas) - Fewer days of sanitation service outages when a climate shock occurs such as a 50-year storm (rural and urban areas) **Reduced losses due to absorptive-related transformative capacity:** - Fewer days of water service outages when a climate shock occurs (rural and urban areas) - Fewer days of sanitation service outages when a climate shock occurs (rural and urban areas) **Enhanced coping ability due to restorative capacity:** - Fewer days to restore water services disrupted by climate shocks - Fewer days to restore sanitation services disrupted by climate shocks **Enhanced coping ability due to restorative-related transformative capacity:** - Fewer days to restore system-wide water services to quality standards after disruption caused by a climate a shock (e.g, 50-year storm, flood, high-velocity wind) - Fewer days to restore system-wide sanitation services to quality standards after disruption caused by climate a shock (e.g, 50-year storm, flood, high-velocity wind)
Climate-resilient infrastructure	
Output indicators	**Absorptive capacity:** - # of water supply and sanitation infrastructure design documents financed with sections that specifically address **robust** and **protected** infrastructure - # of water sources that feed into the potable water supply system **(preparedness, robustness)** **Restorative capacity:** - # of water supply and sanitation infrastructure design-documents with sections that specifically address **redundancies, reparability** of infrastructure - # of water sources that feed into the potable water supply system **(diversification, options)**
Outcome indicators	**Reduced losses due to absorptive capacity:** - Metric of reduced infrastructure damage caused by climate shocks (e.g, 50-year storm, flood, high-velocity wind) - Reduced disruption of water supply - # of households in drought-prone areas that have reliable access to potable water services **Enhanced coping ability due to restorative capacity:** - Fewer days to repair damaged infrastructure caused by climate shocks (e.g, 50-year storm, flood, high-velocity wind) - Reduction in # of households in drought-prone areas without access to quality potable water services during drought event (quality service in terms of water quantity, continuity, and pressure) - Reduction in # of households without access to water after climate shock - Fewer days to restore water supply after climate shock

6.

Takeaways and future work

98. As development financiers strive to support climate adaptation measures that are effective and consistent with countries' climate-resilient development pathways in line with the Paris Agreement, we are confronted with an urgent and increasing need to

- reduce vulnerability to climate variability and climate change effectively,
- ensure that development operations are climate-resilient, contribute to building and strengthening adaptive capacity and to a low-carbon economy,
- monitor and evaluate the success of these measures, and
- establish flexible mechanisms that enable an effective learning process in the use of metrics for climate resilience and that enhance the sharing of knowledge and lessons learned from the implementation of activities that contribute towards mitigation and adaptation.

99. Given this need, this document provides an initial starting point through a general conceptual framework to guide IDB project teams from different sectors in how to identify climate resilience opportunities and define indicators at project level that will facilitate monitoring and assessment of climate resilience results.

100. We have defined climate resilience as the ability of households, communities, and systems to anticipate, absorb, and recover from weather shocks and slow-moving changes, as well as the ability to positively adapt and transform in the face of long-term stresses, change, and uncertainty induced by climate change. As regards climate resilience capacities, we distinguish absorptive capacity, the capacity to take actions *ex ante* to

events after they have happened, that is *ex post*. Both of these capacities can have a transformative dimension to create a fundamentally new system through a systemic shift.

101. We believe that focusing on (transformative) absorptive and restorative capacities will help project teams to design project measures that address specific elements or attributes that enhance these climate resilience capacities: protection, robustness, preparedness, recovery, diversification, redundancy, integration/connectedness, and flexibility, and the related sub-elements modularity, managing slow variables and feedback, learning/awareness, reparability, reconstruction, building back better, polycentric governance systems, complex adaptive systems thinking, and options. These climate resilience elements are an important tool for seizing climate resilience opportunities, designing projects that are climate-resilient and/or build climate resilience, and they help to characterize climate resilience-related project activities at the output level, thus providing a basis for developing output-level climate resilience indicators.

102. At the outcome level, activities that enhance (transformative) absorptive and restorative capacities will contribute to decreased losses (monetary or human) that arise from future climate changes or weather events, and/or an increased ability to cope *ex post* across IDB projects and amongst partner communities, institutions, and clients. These results will be measured by outcome indicators that describe reduced losses or increased coping ability.

103. We hope that the conceptual foundations, guidance, and examples laid out in this document will allow project teams to increasingly seize climate resilience opportunities in IDB projects, to identify suitable results indicators, and to later evaluate the effectiveness of implemented adaptation and climate resilience activities.

104. Designing interventions to build or ensure climate resilience and to lead transformational change is a complex endeavor, so is defining respective results indicators, including adequate targets and baseline data, and attributing observed changes in reduced losses and increased coping ability. However, as project teams and stakeholders across the LAC region will increasingly ensure the climate resilience of development projects and will develop projects that specifically aim at building climate resilience, the understanding of climate resilience opportunities, transformational change, and metrics to effectively and efficiently monitor and evaluate project results will also increase.

105. The present document should be seen as a first step in the implementation of a systematic process to define climate resilience indicators in development operations. This document has provided examples that illustrate the use of the proposed framework in different sectors. Future work within IDB will include the development of respective sectoral briefs that will use this document as a technical reference and will be aimed at providing operational teams with examples of SMART indicators for projects' results frameworks. In the long term, the routine use of the proposed framework in IDB's operations will facilitate the creation of a climate resilience metrics database that could then offer illustrative indicators for specific project types and objectives during the preparation of operations.

ANNEX 1: Glossary of terms

Below we define relevant terms used throughout the document. Many of the definitions have been derived from the Glossary of Terms in the 2019 MDB-IDFC technical paper "A Framework and Principles on Climate Resilience Metrics in Financing Operations" as well as the MDB Paris Alignment guidance notes.

- **Absorptive capacity**, based on our thinking presented in this document, is the capacity to reduce losses resulting from extreme weather events and/or slow-moving changes by taking action *ex ante*.

- **Adaptation/resilience activities** refers to how measures taken to ensure actual or anticipated physical climate risks to an asset, system, community, ecosystem, or business are managed.

- **Adaptation finance** is financing committed to advancing climate-change adaptation and building climate resilience in line with existing MDB/IDFC terminology. Adaptation finance tracking refers to tracking adaptation finance in line with the *Common principles for tracking climate change adaptation finance* (MDBs & IDFC, 2015).

- **Climate-change adaptation** is the process by which human and natural systems adjust to the actual or expected impacts or effects of climate change. It includes adapting to short-term weather fluctuations, inter-annual variability, and longer-term changes over decades, and it relates to adjustments in behaviors, practices, skill sets, natural processes, and knowledge that anticipate short-, medium-, and long-term changes.

- A **climate hazard** is a physical process which has the potential to impact human, environmental, or economic systems and result in the loss of life, loss of livelihoods, asset underperformance, environmental degradation, etc. Climate hazards may be chronic (slow-onset, i.e., progressive shifts in physical climate conditions such as gradual reductions in annual rainfall), or acute (rapid-onset, i.e., extreme weather events, such as floods, cyclones, or storms).

- **Climate resilience**, based on our thinking presented in this document, is the ability of households, communities, and systems to anticipate, absorb, and recover from weather shocks and slow-moving changes, as well as to positively adapt and transform in the face of long-term stresses, change, and uncertainty induced by climate change.

- A country's **climate-resilient development pathway** is defined as a trajectory in which climate change does not prevent progress towards the achievement of sustainable development outcomes (e.g., economic growth, human development, environmental protection, etc.) and, where possible, maximizes the gains from a new climate normal.

- **Climate resilience metrics** are metrics used to measure and assess the extent, quality, and results of adaptation and climate resilience activities.

- **Climate shock** refers to a rapid- or slow-onset impact of climate change.

- **Community** refers to people residing in a particular area or place who are affected by climate change in the same manner due to the common characteristics of the area or place where they live, the environmental resources they depend on, or the climate hazard they are *exposed* to.

- **Impacts** are the long-term effects of the project, directly or indirectly, intended or unintended, that may contribute to longer-term climate resilience, adaptive capacity, and/or reduced climate vulnerability.

- **Inputs** refer to the financial, human, and material resources that are committed in response to the identified project-specific climate resilience priorities in order to integrate appropriate climate resilience considerations into the project.

- **Metric** is used as a catch-all term to capture indicators and/or measures that either qualitatively or quantitatively express the change in climate resilience due to specific project activities.

- **Outcomes** are the likely or achieved short- and medium-term effects of the project, responding to the project-specific context of climate vulnerability in order to build climate resilience. They may take the form of adjustments in physical, human, or environmental systems and associated economic benefits.

- **Outputs** are the products, capital goods, and services that are delivered through the project, responding to the project-specific context of climate vulnerability in order to build climate resilience.

- **Project** refers to a proposed or planned undertaking or operation financed by MDBs or members of the IDFC.

- **Restorative capacity**, based on our thinking presented in this document, is the capacity to recover from losses and damage that result from extreme weather events and/or slow-moving changes by taking actions ex post, including "building back better."

- **System** refers to the wider context (e.g., livelihood, transport and logistics, supply chain, value chain, information and communication, market, ecology) within which assets and/or activities are located that will affect and/or be affected by the extent to which project inputs will deliver outputs that generate outcomes and impacts within the project vulnerability context.

- **System level** refers to the climate resilience, achieved through the project, that benefits the wider system in which the assets and/or activities are located, focusing on climate resilience as a public good.

- **Transformational adaptation**, according to the IPCC, seeks to change the fundamental attributes of systems in response to actual or expected climate change and its effects, often at a scale and ambition greater than incremental activities. It includes changes in activities, such as changing livelihoods from cropping to livestock or migrating to take up a livelihood elsewhere, and also changes in our perceptions of and paradigms about the nature of climate change, adaptation, and their relationship to other natural and human systems.

- **Transformative** (absorptive- or restorative-related) **capacity**, based on our thinking presented in this document, is the capacity to create a fundamentally new system through a systemic shift.

ANNEX 2: Conceptual basis for our understanding of climate resilience

1 In this annex we will provide the conceptual basis for our argument that the clearest distinction between resilience capacities is found between absorptive, restorative, and transformative capacities.

2. Table 18 presents the mathematical notations that will be used for easier reference.

Table 18: Mathematical notations used

Letter/symbol	Meaning
C	Ability to recover represented by restorative capacity
δ	Weighting factor when translating greater resilience into welfare
ER	Expected climate resilience
EW	Expected household welfare
W	Weather event
L	Losses represented by absorptive capacity
S	Characteristics of the relevant systems within which project beneficiaries operate
X^{L}	Actions that can be taken to reduce losses represented by climate resilience elements
X^{C}	Actions that can be taken to increase coping ability represented by climate resilience elements
Y^{HH}	Household characteristics
Z^{L}	Relevant local characteristics
•	External weather and systems characteristics

3. To begin with, there are three main characteristics that determine climate resilience: exposure, sensitivity, and the ability to recover. Exposure can be characterized by the distribution of expected weather events both currently and over a relevant timespan, for instance, over the life of infrastructure.[31] Sensitivity is the extent to which damage or loss occurs for any given weather event. And ability to recover or cope – either return to an original state, or to an original rate of growth – is characterized by actions that are taken in response to a given weather event. Equation 1 below succinctly captures this definition of expected resilience over some time period, t=1 to T:

$$\mathrm{ER} = \sum_{t=1}^{T} \int_{i=\underline{W}}^{i=\overline{W}} \left[L\left(X_{it}^{L}; W_{it}, S_{it}^{1} - S_{it}^{N}\right) + C\left(X_{it}^{C}; W_{it}, S_{it}^{1} - S_{it}^{N}\right) \right] \quad [1]$$

[31] We recognize that that the distribution of weather events at future points in time will itself be characterized by uncertainty.

4. In each time period, there is a distribution of weather events, i , which is bounded between $\underline{W}$ and $\bar{W}$ and each event is associated with a loss, $L\left(X_{it}^{L};W_{it},S_{it}^{1}-S_{it}^{N}\right)$ and coping ability, $C\left(X_{it}^{C};W_{it},S_{it}^{1}-S_{it}^{N}\right)$. For most adaptation projects, we are mainly concerned with $L\left(X_{it}^{L};W_{it},S_{it}^{1}-S_{it}^{N}\right)$ and $C\left(X_{it}^{C};W_{it},S_{it}^{1}-S_{it}^{N}\right)$, which we will label absorptive and restorative capacity, respectively. In addition to the distribution of weather events, losses and coping ability are also a function of the resilience characteristics of the relevant systems within which project beneficiaries operate, $S_{it}^{1}-S_{it}^{N}$. Most importantly, they are also a function of actions that can be taken to reduce losses or increase coping ability, X_{it}^{L} and X_{it}^{C}. We can think of X_{it}^{L} and X_{it}^{C} as being comprised of the elements of resilience, e.g. **robustness, preparedness, flexibility,** etc. Project activities/inputs, then, will generate outputs that increase either $L\left(X_{it}^{L};W_{it},S_{it}^{1}-S_{it}^{N}\right)$ and $C\left(X_{it}^{C};W_{it},S_{it}^{1}-S_{it}^{N}\right)$, or both.

5. With respect to transformative capacity, we note that this capacity is generally defined in terms of system-level capacity to change, and so we capture the potential for project activities to generate outputs that increase transformative capacity as those activities that directly increase some aspect of system resilience. As an example, consider that a project that has activities to reduce losses by increasing the resilience of relevant system, S_{it}^{1}. We can re-write [1] to capture project activities that contribute to system one's resilience as follows:

$$\text{ER}=\sum_{t=1}^{T}\int_{i=\underline{W}}^{i=\bar{W}}\left[L\left(X_{it}^{L},S_{it}^{1}\left(X_{it}^{S}\right);W_{it},S_{it}^{2}-S_{it}^{N}\right)+C\left(X_{it}^{C};W_{it},S_{it}^{1}-S_{it}^{N}\right)\right] \quad [2]$$

6. As written in [2], the relevant system, project activities to reduce losses increase households' absorptive resilience directly, and also indirectly through activities that also increase S_{it}^{1}. We consider the increase S_{it}^{1} as an increase in transformative capacity.

7. Equations [1] and [2] have clear implications for the development of a project's theory of change. Activities to increase all three resilience capacities of specific stakeholders will generate outputs that increase $X_{it}^{L,C,S}$. The extent to which inputs, captured in higher $X_{it}^{L,C,S}$ leads to the output of greater expected resilience, ER, now and over time, will depend on the distribution of weather events and resilience characteristics of the relevant systems. In many cases, at least some key assumptions needed to assure that higher leads to greater ER will be based on assumptions regarding relevant systems resilience characteristics, and particularly how these might change over time. It will also depend on baseline levels $X_{it}^{L,C,S}$ on which the project is building. For instance, the project may aim to increase robustness, but the extent to which increased robustness leads to greater reduction in losses may well depend on other elements, such as preparedness and integration/connectedness. Thus, to generate meaningful increases in outcomes, assumptions on the levels of complimentary resilience elements may be required.

8. Next, we consider how the outputs, greater expected resilience, leads to outcomes, for instance, greater expected household welfare. Equation 3 below presents a simple expression:

$$EW = \sum_{t=1}^{T} \hat{W}\left(Y_t^{HH}, Z_t^L, \hat{S}_t^1 - \hat{S}_t^N\right) + \delta ER \quad [3]$$

9. Here, EW is expected household welfare over some relevant timeframe and ER is again expected resilience. Expected resilience is weighted by δ, which translates greater resilience into welfare. Finally, $\sum_{t=1}^{T} \hat{W}\left(Y_t^{HH}, Z_t^L, \hat{S}_t^1 - \hat{S}_t^N\right)$ is the sum of average welfare over the relevant timeframe. Average welfare is a function of household characteristics, Y_t^{HH}, relevant local characteristics, Z_t^L, and average systems characteristics, $\hat{S}_t^1 - \hat{S}_t^N$. Using this simple representation, there is a direct link between increased resilience and expected welfare that is not mediated by average household welfare. Additionally, it is likely that δ will be related to household, local and systems-level characteristics, though we ignore this here.

10. Equation [3] does not allow for stakeholders to make choices; rather, there is a given average welfare, so that expected welfare is then exogenously increased through project activities. This representation may be suitable when two conditions are met: 1) An argument can be made that there will be limited impacts on stakeholders' "choices" in response to the increased resilience. For instance, upgraded, resilient roads allow people to continue traveling those roads even under extreme weather, as they would do under normal weather. But we do not expect greater-than-normal traffic to occur under extreme weather. 2) Project activities are not based on changing stakeholders' incentives to change their own behaviors and practices. Benefits to building new, or climate-proofing existing, infrastructure does not rely on changes in stakeholder behavior, for instance. Incentivizing farmers to create buffer zones along riparian corridors, however, relies on changes in farm practices.

11. Consider the case where conditions 1) and 2) are not met, that is, project activities are based on altering stakeholders' incentives to change their own behaviors that affect both average welfare as well as resilience. Many climate resilient projects in the agricultural sector, for instance, aim to increase adoption of climate resilient practices, either through information exchange, demonstration plots, or subsidies to inputs needed to implement climate resilient practices. Equation [4] below provides a simplified expression under these conditions:

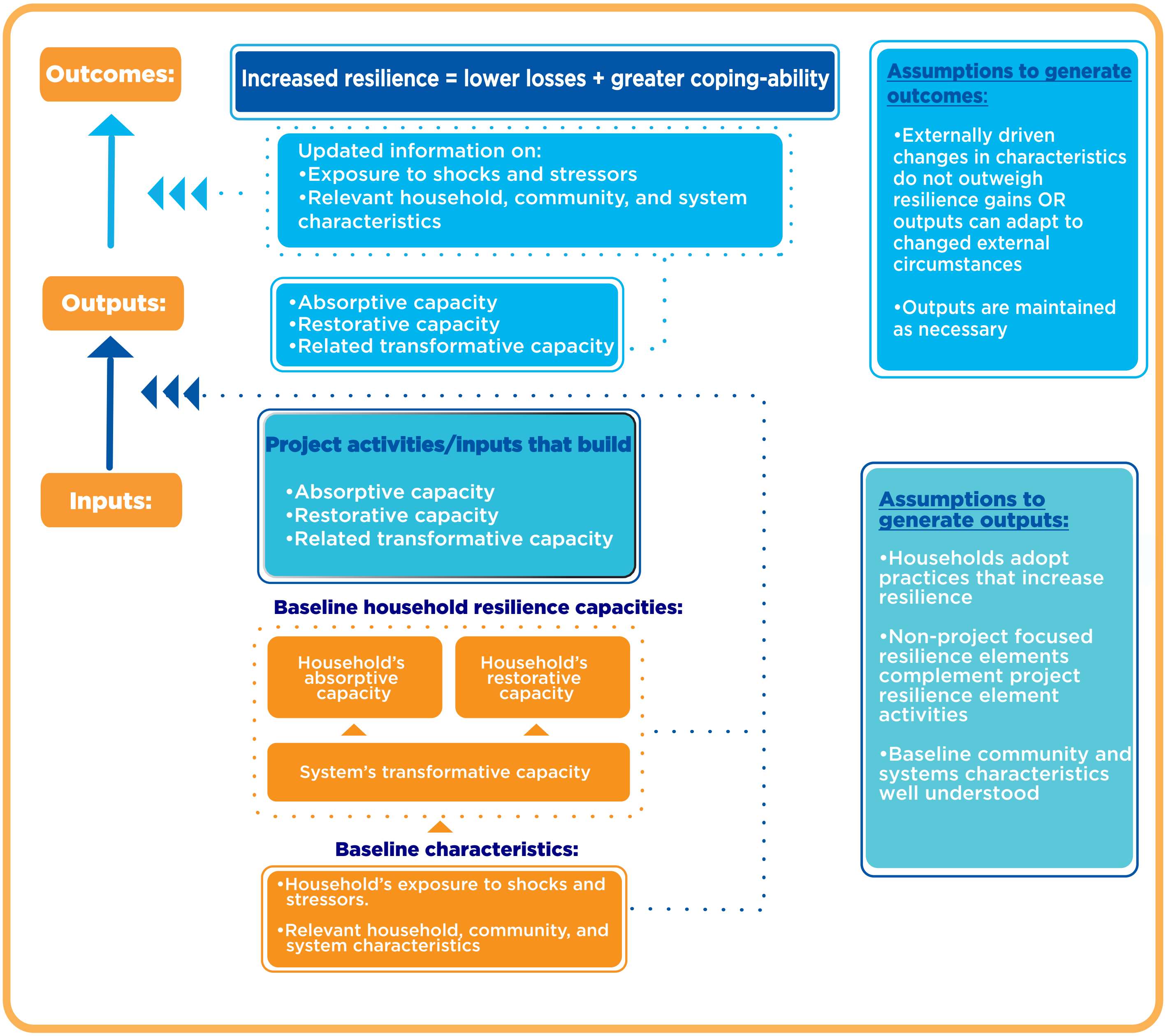
$$EW = \sum_{t=1}^{T} \hat{W}\left(X_{it}^W, X_{it}^L, X_{it}^C; \bullet\right) + \delta \sum_{t=1}^{T} \int_{i=\underline{W}}^{i=\overline{W}} \left[L\left(X_{it}^L; \bullet\right) + C\left(X_{it}^C; \bullet\right)\right] - c_W X_{it}^W - c_L X_{it}^L - c_C X_{it}^C \quad [4]$$

12. To simplify the equation, we represent external weather and systems characteristics with a dot, $\bullet$, but stress that they remain important factors for determining whether project outcomes will lead to project impacts. In equation [4], average welfare is a function of absorptive and restorative capacity, as well as household decision variables, X_{it}^W. Certain project activities may generate both greater average welfare – e.g. higher average crop income – and reduce losses from weather shocks. Whether farm households will adopt practices that increase anticipatory and recovery capacity will depend on whether such benefits exceed costs.

13. Finally, to keep things simple, we have specified fixed costs to all of the inputs. However, just as with average welfare and resilience capacities, these costs may also be a function of household, local, and systems level characteristics.

14. To summarize, in our conceptual framework, we model absorptive capacity as reducing damages and losses to either weather shocks or long-term climate changes, restorative capacity as increasing the ability to cover losses and damages and return to an “average” state or level of growth, and transformative capacity as increasing systems-level resilience. It is worth stressing that the equations used to capture how resilience can be incorporated into a theory of change – and the schematic representation depicted in Figure 8 below – are broad conceptual frameworks to be used as guidelines for projects to develop the theory of change. As described in section 4.3 Thinking about multi-dimensionality, fitting the purpose, and context-specificity, the application in any particular project will require greater specificity, and potentially great complexity, in mapping the relationships in the causal chain.

Figure 8: Conceptual Framework: Applying Resilience to the theory of change (same as Figure 4)



References

Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, 16(3), 268-281.

African Development Bank, Asian Development Bank, Asian Infrastructure Investment Bank, European Bank for Reconstruction and Development, European Investment Bank, Inter-American Development Bank, International Development Finance Club, & Islamic Development Bank. (2019). *A framework and principles for climate resilience metrics in financing operations.* IDB. DOI: http://dx.doi.org/10.18235/0002040.

Allen, S., Gonzales Iwanciw, J., Rodríguez, L., Stoffel, M., Grunwaldt, A., Brusa, F., & Bocco, M. J. (2020). *Building transformative institutional adaptive capacity: Assessing the potential contribution of PPCR to build a climate resilient water governance framework in the plurinational state of Bolivia.* IDB. DOI: http://dx.doi.org/10.18235/0002226.

Barandiarán, M., Esquivel, M., Lacambra, S., Suárez, G., & Zuloaga, D. (2019). *Disaster and climate change risk assessment methodology for IDB projects: A technical reference document for IDB project teams.* IDB. DOI: http://dx.doi.org/10.18235/0002041.

Béné, C., Wood, R. G., Newsham, A., & Davies, M. (2012). *Resilience: New utopia or new tyranny? reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes.* Institute of Development Studies.

Biringer, B., Vugrin, E., & Warren, D. (2013). *Critical infrastructure system security and resiliency.* CRC Press.

Carpenter, S. R., Walker B. H., Anderies, J. M., & Abel. N. (2001). *From metaphor to measurement: resilience of what to what? Ecosystems,* 4(8), 765-781. DOI: 10.1007/s10021-001-0045-9

Cohen-Shacham, E., Walters, G, & Maginnis, S. (2016). *Nature-based solutions to address global societal challenges*. International Union for Conservation of Nature. https://doi.org/10.2305/IUCN.CH.2016.13.en

Constas, M. A., Frankenberger, T. R., & Hoddinott, J. (2014a). *Resilience measurement principles: Toward an agenda for measurement design.* World Food Programme.

Constas, M. A., Frankenberger, T. R., Hoddinott, J., Mock, N., Romano, D., Béné, C. & Maxwell, D. (2014b). *A common analytical model for resilience measurement: Causal framework and methodological options.* World Food Programme.

Ellis J. (2014). Climate resilience indicator literature review. Prepared as part of *Using Columbia Basin state of the basin indicators to measure climate adaptation.* Columbia Basin Trust.

EU-CIRCLE. (2016).). *Pan-European Framework for Strengthening Critical Infrastructure Resilience to Climate Change – Initial Version.* https://www.eu-circle.eu/

Folke, C. (2006). Resilience: The emerging of a perspective for social-ecological systems analyses. *Global Environmental Change,* 16(3), 253-267. DOI:10.1016/j.gloenvcha.2006.04.002

Guidance for Resilience in the Anthropocend: Investments for Development. (2020). Applying resilience thinking: Seven principles for building resilience in social-ecological systems. GRAID at Stockholm Resilience Center. https://applyingresilience.org/

Hill, M. (2013). *Climate change and water governance. Adaptive capacity in Chile and Switzerland.* Springer.

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics,* 4, 1-23.

IDB. (2007). Disaster Risk Management Policy (OP-704). https://idbdocs.iadb.org/

IDB. (2016). Bahamas Resolution (Resolution AG-6/16 AND CII/AG-2/16). https://www.iadb.org

IDB. (forthcoming). *Nature-based solutions in Latin America and the Caribbean: Support from the IDB Group.* IDB.

IDBG. (2018). *What is sustainable infrastructure? A framework to guide sustainability across the project cycle.* IDBG. DOI: http://dx.doi.org/10.18235/0001043

IDBG. (2020). *IDB Group corporate results framework 2020-2023.* IDBG. DOI: http://dx.doi.org/10.18235/0002287

IPCC. (2014). Climate change 2014: Impacts, adapatation, and vulnerability. Part A: Global and sectoral aspects. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir (Eds.), *Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* 1-1150. Cambridge University Press.

Jagustović, R., Zougmoré, R. B., Kessler, A., Ritsemaa, C. J., Keesstra, S., & Reynolds. (2019). Contribution of systems thinking and complex adaptive system attributes to sustainable food production: example from a climate-smart village. *Agricultural Systems* 171, 65-75.

Lempert, R. J., Miro, M., & Prosdocimi, D. (2021). *A DMDU guidebook for transportation planning under a changing climate.* IDB. DOI: http://dx.doi.org/10.18235/0003042

Lonsdale, K., Pringle, P., & Turner, B. (2015). *Transformative adaptation: What it is, why it matters and what is needed.* UK Climate Impacts Programme, University of Oxford.

Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., & Nelson, D. (2010). Resilience and vulnerability: Complementary or conflicting concepts. *Ecology and Society, 15(3)*, 1-25.

Multilateral Development Banks (MDBs; African Development Bank, Asian Development Bank; Asian Infrastructure Investment Bank, European Bank for Reconstruction and Development, European Investment Bank, Inter-American Development Bank, Islamic Development Bank, World Bank). (2018). Joint MDB declaration regarding alignment approach to the objectives of the Paris Agreement. https://thedocs.worldbank.org/

MDBs. (2020). 2019 *Joint report on multilateral development banks climate finance.* DOI: http://dx.doi.org/10.18235/0002528

MDBs (2020). *MDB climate finance tracking methodologies.* DOI: http://dx.doi.org/10.18235/0002528

MDBs & IDFC. (2015). *Common principles for climate change adaptation finance tracking. https://www.eib.org/*

MDBs & IDFC. (2017). *One planet summit - Joint IDFC-MDB statement. https://www.afdb.org/*

ODI. (2016). *Analysis of resilience measurement frameworks and approaches.* Overseas Development Institute.

OECD. (2014). Guidelines for resilience systems analysis. OECD Publishing.

UNFCCC. (2015). Paris Agreement.

UNISDR. (2015). *Sendai Framework for Disaster Risk Reduction:* 2015-2030. [Paper presentation.] Third UN World Conference on Disaster Risk Reduction in Sendai, Japan.

UNISDR. (2016). Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction. United Nations Office for Disaster Risk Reduction.

Walker, B., Carpenter, S., Anderies, J., Abel, N., Cumming, G. S., Janssen, M., Lebel, L., Norberg, J., Peterson, G. D., & Pritchard R. (2002). Resilience management in social -ecological systems: A working hypothesis for a participatory approach. *Conservation Ecology, 6*(1),14.

World Bank. (2017).*Operational guidance for monitoring and evaluation (M&E) in climate and disaster resilience-building operations.* World Bank Group. https://www.worldbank.org

World Bank. (2018). *Fiscal policies for development and climate action.*
World Bank Group. https://www.worldbank.org

World Bank. (2020a). *Enhancing climate resilience through resilience attributes - Good practices and guidance note.*

World Bank Group. https://www.worldbank.org Martin, N. L., & Siddiqi, S. N. (2020b). *World Bank guidance note on climate indicators.* The World Bank.

WWAP/UN-Water. 2018. The United Nations world water development report 2018: Nature-based solutions for water." UNESCO. http://unesdoc.unesco.org/images/0026/002614/261424e.pdf.

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