Supported by

The Rockefeller Foundation

CDRI

Coalition for Disaster Resilient Infrastructure

Physical Climate Risk Assessment for the Financial Sector

Playbook

About Us

The Rockefeller Foundation commissioned and funded this initiative. The Coalition for Disaster Resilient Infrastructure (CDRI) led the development and authorship of this report.

CDRI
Coalition for Disaster Resilient Infrastructure

The Coalition for Disaster Resilient Infrastructure (CDRI) is a partnership of national governments, UN agencies and programmes, multilateral development banks and financing mechanisms, the private sector, and academia that promotes the resilience of new and existing infrastructure systems to climate and disaster risks, thereby ensuring sustainable development.

The Rockefeller Foundation

The Rockefeller Foundation is a pioneering philanthropy built on collaborative partnerships at the frontiers of science, technology, and innovation that enable individuals, families, and communities to flourish. The Foundation makes big bets to promote the well-being of humanity. Today, the Foundation is focused on advancing human opportunity and reversing the climate crisis by transforming systems in food, health, energy, and finance.

Disclaimer

This document is a general advisory that highlights key physical climate risks faced by financial institutions with exposure to the infrastructure sector and the methodology these institutions can follow to assess and navigate these risks. It leverages data from public and private sources to underscore the scope and severity of climate hazards faced by infrastructure sector in LMICs. However, these are meant to be read as indicative trends only and not as definitive forecasts or as endorsements of any data source. The analysis also does not necessarily represent the views of The Rockefeller Foundation or CDRI, including its member countries, organizations, partners, or other stakeholders.

Physical Climate Risk Assessment for the Financial Sector

Design and Layout: An Eye On

Acknowledgements

CDRI would like to extend sincere gratitude to all those who contributed to the development of this report and The Rockefeller Foundation for commissioning this initiative and providing their invaluable guidance throughout the process. CDRI greatly appreciates the substantive support Dalberg Advisors provided in drafting the Playbook.

The authors would also like to extend immense gratitude to all the organizations and institutions that actively engaged with us and shared their invaluable perspectives on the physical climate risks confronting the financial sector in India. Their collaboration and inputs were indispensable in ensuring the relevance and applicability of the playbook. The organizations that the authors of the playbook would like to acknowledge for their contributions are as follows:

Banks and Insurance Companies	• Axis Bank • Bajaj Allianz • ICICI Bank • IndusInd Bank • India Infrastructure Finance Company Limited • Standard Chartered Bank • State Bank of India • Union Bank of India
Multilateral Organizations	• International Finance Corporation • United Nations Environment Programme Finance Initiative
Climate Data and Advisory Service Providers	• auctusESG • AXA Climate • Blue Sky Analytics • Climate Policy Initiative • Civic Data Lab • Climate AI • Dalberg • Fathom • StepChange and Tonkin + Taylor
Universities and Academia	• Tohoku University • Victoria University of Wellington
Others	• Access Corporate Finance • Catapult • Climate Bonds Initiative • Climate Finance 2050 Limited • Climate Resilience for All • International Coalition for Sustainable Infrastructure

Together, the collective efforts of these partners have culminated in the development of a resource that aims to enhance the resilience of the Financial sector in LMICs in the face of physical climate risks.

Special thanks

to those who generously provided case studies to bring our analysis to life and to those who provided climate hazard data and quantitative analysis for our work

AXA Climate · Climate Bonds Initiative · Union Bank of India · ClimateAi

Foreword

Amit Prothi
Director General,
Coalition for Disaster Resilient Infrastructure (CDRI)

Deepali Khanna
Vice President,
Asia Regional Office
The Rockefeller Foundation

The Rockefeller Foundation and the Coalition for Disaster Resilient Infrastructure (CDRI) are pleased to present the Playbook on "Physical Climate Risk Assessment for the Financial Sector" as an initiative to help financial institutions navigate the evolving landscape of physical climate risks. This Playbook is designed to be a first step towards empowering financial institutions across several LMICs to navigate the evolving landscape of physical climate risks.

In developing countries, huge amounts of infrastructure investments are being made by the financial sector and the escalating impacts of climate change present an undeniable and growing challenge for financial institutions. Physical climate risks—from extreme weather events to chronic shifts in climate patterns—pose an increasing threat to infrastructure assets. As a result, financial institutions, with their significant exposure to these assets, face a heightened level of risk. Understanding and proactively managing these climate-related physical risks is now imperative for the financial sector. However, despite the growing recognition of these risks, the adoption of mechanisms for their assessment and management is still at a nascent stage in most LMICs.

We have consulted widely and presented the Playbook at major forums including London Climate Action Week, and are confident that it will serve as a crucial resource for financial institutions in navigating the complex of translating broad climate projections into localized asset-level risks. This LMICs focused Playbook, builds upon regulatory frameworks from regulator and international guidelines, and translates complex concepts into actionable strategies. It provides step-by-step guidance for assessing and managing the physical climate risks associated with infrastructure assets and projects. It is great to see that the initiative has been positively received in consultations and the endorsements have come from across the industry.

The Rockefeller Foundation is committed to addressing climate change and supporting adaptation efforts that can support the resilience of vulnerable communities and economies. Climate change is among the most pressing crises facing the world today. As lives and livelihoods get disrupted via increasing frequency and severity of climate-linked disasters, the vulnerable populations will be most severely impacted. Infrastructure plays a critical role in ensuring the availability of goods and services for improving the livelihoods of people and communities. Therefore, it is critical to improve the climate resilience of infrastructure. The assessment of physical climate risks that can affect the infrastructure is an important first step in enhancing the resilience of the infrastructure.

We believe that this playbook holds the potential for a paradigm shift in the financing landscape, paving the way for innovative financial models and instruments that, in the longer term, can catalyze financing towards the most climate vulnerable regions and drive adaptation finance. By enabling financial institutions to better understand and reduce the risk profile of infrastructure investments, we envision that the playbook will unlock new financing opportunities for climate-resilient assets in LMICs. Doing so will not only chart a course towards economic resilience but also unlock finance flow towards regions highly vulnerable to climate change, and improve the lives and livelihoods of communities.

We hope this playbook proves as a valuable resource in financial institutions' journey of integrating physical climate risk assessments into their decision-making.

About the playbook

The need for financial institutions (FIs) to account for physical climate risks in their risk management has never been more urgent. As the impacts of climate change escalate, businesses must take proactive steps to understand the level of risk they face and to minimize business disruption. These risks can take the form of physical risks (e.g., extreme weather events) and transition risks (e.g., policy shifts). This playbook focuses on the former, which can lead to widespread damage to business and business activities, with severe financial implications. FIs (e.g., banks and non-banking financial companies) are especially at risk given their large exposure to other vulnerable industries through their credit or client portfolios. The rapidly evolving regulatory landscape increasingly requires FIs to account for these risks in their overall business strategy and core business activities, such as lending.

This playbook provides guidance to FIs on assessing the physical climate risks for their infrastructure investments, and steps they can take to manage these risks. The playbook covers strategies and tactics that financial institutions can follow to assess and manage their exposure to physical climate risks for the infrastructure assets and projects they support. The playbook builds on the following established frameworks:

The guidelines and recommendations attempt to illustrate how FIs can navigate the complexities of undertaking physical climate risk assessment for their assets (e.g., due to data-related constraints). It is specifically designed keeping in mind the LMICs context. However, the playbook's principles and recommendations are transferable and can be adapted by financial institutions across developing countries.

The intended audience for this playbook consists of the leadership and risk management teams of financial institutions, that can put these recommendations into practice. Financial institutions and professionals employed in these institutions could benefit from this playbook by gaining a better understanding of the types of physical climate risks that are relevant to the infrastructure assets they support, the financial implications of these risks, and the established frameworks to manage them. It further also helps them adapt their internal risk management processes and guide other business functions (e.g., credit).

Limitations

While the playbook provides practical guidance on physical climate risk management for infrastructure sector exposure, as with any publication of this nature, there are certain constraints inherent in the preparation of this playbook. These constraints limit how the playbook can be leveraged by financial institutions and are listed below:

- While the playbook acknowledges the different types of risks an FI might face due to climate hazards, the overarching focus is on understanding the impact of these hazards on the financial performance of a specific asset. Other forms of risks (e.g., balance sheet risk) are not covered in this document.
- The Playbook provides high-level guidance that FIs can adapt and adopt to fit their needs and purposes. However, it is not intended to serve as a detailed manual or reference that enumerates all climate-related policies, compliance requirements and regulations, operational details of assessing the risk, etc., for financial institutions.
- The recommendations are based on currently established frameworks. However, this space is evolving. The recommendations contained in the playbook will need to be adapted as new frameworks and practices emerge, especially from financial regulators.

Endorsements

With increasing climate change, understanding and assessing climate risks are assuming greater importance for banks in India. The Playbook on Physical Climate Risk Assessment for the Financial Sector stands as an important body of work, empowering bankers to navigate this critical challenge. This timely Playbook equips banks with a robust framework for assessing and integrating physical climate risks into their decision-making. Moreover, the inclusion of compelling real-world case studies brings the framework to life, ensuring a truly enriching learning experience.

Anand Vishwanathan
EVP and Head, Market & Liquidity Risk
& ERM & Model Risk,
Axis Bank

The banking sector in India is at an early stage of thinking about physical climate risks and their potential financial implications. The Playbook on Physical Climate Risks for the Financial Sector is a pivotal resource for banking professionals to refer to as they build their understanding and capabilities on this issue. The playbook is a very useful how-to guide that is firmly rooted in Indian ground realities, offering practical insights on what's feasible within the current context, making it highly relevant for banking professionals.

Manish Kumar
Head, ESG, ICICI Bank

The development of this playbook is a commendable effort that fills a critical gap in the market. It goes beyond merely painting an idealized picture, offering practical and actionable recommendations that bridge the gap between theory and application. It helps financial institutions navigate the complexities of physical climate risk assessment, equipping them with the necessary knowledge and tools to future-proof their businesses against the evolving climate landscape.

Deepak Kumar
Head, (ESG Cell),
Union Bank of India

The Playbook on Physical Climate Risks for the Financial Sector is an impressive document that builds on global best practices to provide a structured path for navigating the complexities of physical climate risk assessment. It doesn't merely paint an idealized picture, but also provides practical and actionable recommendations, bridging the gap between theory and application. I am sure it will be a helpful guide for stakeholders as they think about the way forward.

Neha Kumar
Head, South Asia Programmes,
Climate Bonds Initiative

The Playbook on Physical Climate Risks for the Financial Sector is a landmark piece of work, that draws heavily on the expertise of a diverse coalition of relevant stakeholders: bankers, insurers, data scientists, climate experts, and more. Furthermore, its guidance, especially on integrating climate risk considerations within financial institutions, anchors closely on guidelines that have emerged from the Reserve Bank of India, making it very actionable for the financial sector.

Sourajit Aiyer
Vice President - Sustainable Finance
& Climate Strategy, auctusESG

Table of Contents

Executive summary (1/6)

Context and challenge

Infrastructure acts as the foundational pillar for any nation's economic growth and the pace at which it has been built globally in the last 50 years is impressive. Despite this significant achievement 60% of the infrastructure required by 2050 is yet to be built, which as per global estimates will require investments to the tune of US$ 9.2 trillion, of which LMICs will require at least 30%. Furthermore, Climate change is increasing the intensity and frequency of hazards, posing significant risks to the existing and yet-to-be-built infrastructure. This reinforces the need for financial institutions in LMICs that understand climate and disaster risks to infrastructure assets and factor that into their investment processes.

Need for the playbook

The Rockefeller Foundation (RF) and the Coalition for Disaster Resilient Infrastructure (CDRI) have come together to combine their unique strengths to catalyze the ecosystem to ensure FIs actively assess and manage physical climate risks. RF brings with it a deep understanding of the climate space and has the ability to leverage its philanthropic capital to shape the sector through research and pilots. CDRI brings expertise in resilient infrastructure and, given its status as an international coalition, is ideally suited to serve as a platform to influence key stakeholders and drive collaboration.

RF and CDRI have commissioned this playbook to provide FIs in Low and Middle Income Countries (LMICs) a better understanding of physical climate risks by providing contextualized guidance that draws from global good practices. RF and CDRI recognized that embedding physical climate risk assessment and management in FIs doesn't require a revolution, but rather an evolution that builds on existing knowledge, guidelines, and systems. Therefore, the playbook has been designed to build on existing global good practices and draws from works by organizations such as NGFS and UNEP FI's Climate Risk and Task force on Climate related financial disclosures (TCFD) programme.

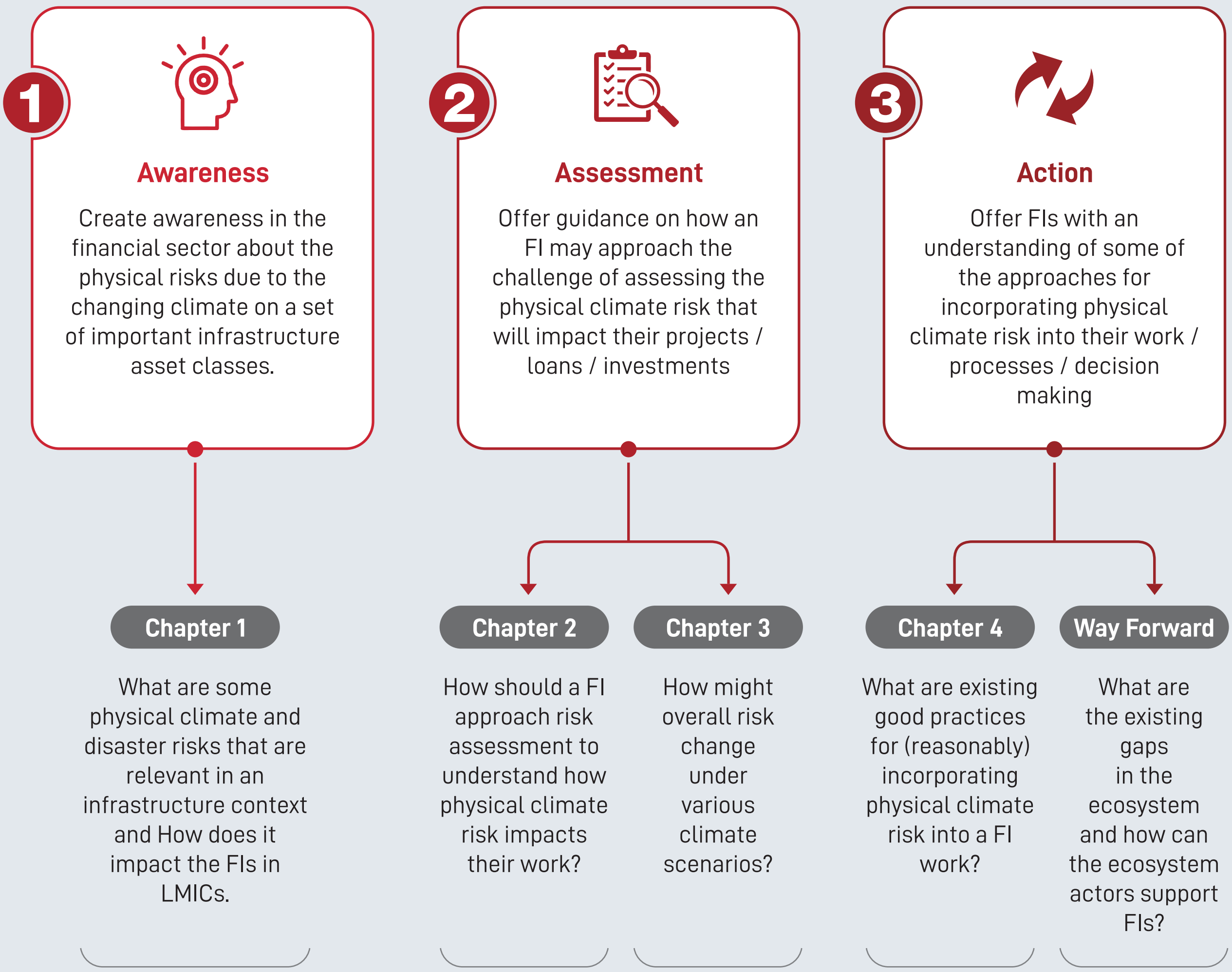
The playbook complements existing tools and resources developed by CDRI, such as the Global Infrastructure Risk Model and Resilience Index (GIRI), to help FIs better understand the physical climate risks that infrastructure sectors face. CDRI's GIRI platform is an open source, first of its kind, public data platform that provides a probabilistic view of losses that can accrue to different infrastructure asset classes under impact of different types of physical climate and other geological hazards. GIRI can serve as a valuable preliminary tool for financial institutions to gain early insights into the regions and assets at risk. Further, GIRI's open-source nature offers additional advantages during the climate risk assessment process. The data and models utilized by GIRI can supplement and complement the risk models used by banks, thereby increasing the efficiency and effectiveness of the analysis.

Executive summary (2/6)

Overview of the playbook

The playbook takes a structured approach to understanding physical climate risks and focuses on three key areas – awareness, assessment; and action. The figure below provides an overview of the key areas and the associated chapters covered in the playbook.

Figure 1: Key areas and associated chapters



The key findings and insights for each chapter are summarized in the subsequent pages.


Manukau
Hamilton
Waitakere
Helensville

Executive summary (3/6)

Chapter 1: Impacts of physical climate risks on critical infrastructure and financial institutions

Infrastructure is not just a fundamental piece in achieving economic growth but is also vital to achieving the Sustainable Development Goals (SDGs). More than 90 percent of infrastructure around the world has been built in the last 50 years alone and about 60 percent of the infrastructure required by 2050 is yet to be built. It is estimated that the global infrastructure investment needed annually to address infrastructure deficits, achieve the SDGs, and achieve net zero by 2050 will be in the tune of US$ 9.2 trillion. Out of this, LMICs will require US$ 2.76 trillion – which is 30 percent of the annual total investment needed. This reinforces the need for financial institutions that understand climate and disaster risk to infrastructure assets and utilize them in funding of assets.

Chapter 2: Methodology to assess FI's exposure to physical climate risks

Drawing from global good practices published by organizations such as NGFS and TCFD, financial institutions can follow a four-phase process to assess physical climate risks that will impact their projects / loans / investments. Further, timely, consistent, and accurate disclosures are expected to help FIs form a more precise picture of the physical climate risks that they face and can thereby facilitate more informed decision making on risk management. The four phases that FIs can look to follow are:

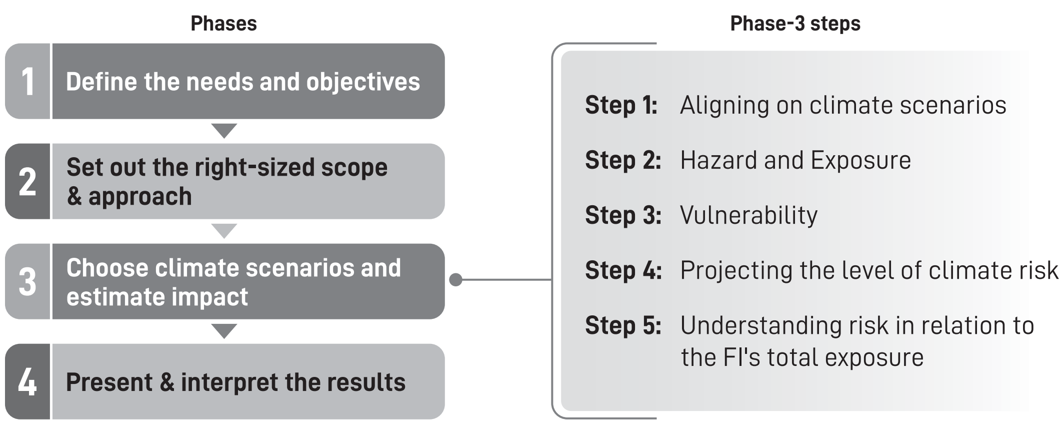
Phase-1: Define the objectives of the assessment to ensure alignment with organizational goals and regulatory requirements

Phase-2: Convert the objective into a clear scope, laying out the depth of assessment required and how it will be used for decision making

Phase-3: Assess the hazard, exposure, and vulnerability of an asset to physical climate risks and translate these into a climate value-at-risk (VaR) or thematic score to understand the overall risk level for the asset. This should further be translated into total exposure of the physical climate risks that the FI faces.

Phase-4: Form a holistic picture of physical climate risks by (i) interpreting the physical climate risk assessment in light of its underlying assumptions (e.g., bearing in mind how these assumptions ultimately place a limit on the accuracy of projections) and (ii) combining the assessment with other modelling and analyses

Figure 2: Process to conduct physical climate risk assessment



Executive summary (4/6)

Given the complexities, FIs will need to ultimately embed physical climate risk assessment. Some of the key suggestions as FIs embark on this journey are:

- Begin with a qualitative thematic approach to assessing risk and gradually build towards adopting a more quantitative VaR based approach as capabilities evolve
- Leverage external service providers to allow for a quicker adoption of physical climate risk assessment while simultaneously invest in internal capacity building to gradually shift some of the analysis in-house

Chapter 3: Using scenarios to determine inputs for impact model

Climate scenarios are important tools for FIs to assess climate risk. However, FIs need to build their own models that anchor on climate scenarios, to assess how assets in their portfolio are exposed to climate risks. FIs can use existing scenarios but it's important to consider a range of possibilities to effectively manage risks. While scenarios provide a general future view, they often don't capture specific climate hazards, which is why FIs need to build internal models to be able to assess the expected financial impact due to climate hazards. This can be complex, so FIs could consider collaborating with external experts or develop a simpler qualitative model to get a preliminary sense of the risk.

FIs can adopt a three-step approach to convert climate scenarios into internal models that can help assess the expected financial impact on an FI due to climate hazards. The figure below provides a brief description of this three-step process.

Figure 3: Three-step process for converting climate scenarios into a localized exposure model

	Step 1	Step 2	Step 3
Process	**Choose or develop the climate scenario for inputs (e.g., RCP 8.5)[a]**	**Leverage scenarios to develop internal hazard and exposure models[b]**	**Combine the inputs from the internal model with vulnerability and FI exposure to model impact for FIs[c]**
Objective	Fis need to understand how climate change may evolve in order to understand risk and make financial decisions. The scenarios reflect FIs' view of future climate conditions (e.g., based on policy action, etc.), and allow them to test a range of potential pathways.	The chosen scenarios (from Step 1) can provide a global / regional view of the climate situation, but need to be adapted to provide reliable inputs on specific hazards and exposure at a sufficient spatial and temporal resolution.	The outputs from the internal model developed in step 2 will serve as inputs into the impact assessment model in step 3. The outputs from the internal model will need to be combined with vulnerability data.
Inputs	• Inputs can include a range of hazards, global warming pathways, time horizons, etc • Publicly available sources (e.g., RCP 8.5) could be used • Bespoke scenarios that reflect the FIs views can be developed either internally or by hiring service providers	• Scenario(s) modeled in Step 1 • Geographically specific asset data and other information related to the asset. For example, construction material, age, height and construction quality, etc • Qualitative view of local climate conditions	• Hazard and exposure data modeled in Step 2 • Sectoral nuance • Vulnerability and FI exposure data
Outputs	• A range of hazard figures that reflect a view of expected climate outcomes • Good practice would include at least two scenarios (e.g., baseline case, worst case) so that a range of inputs can be tested across time frames	• Expected frequency and severity of relevant hazards at the desired spatial resolution specific to the transaction • E.g., number and severity of tropical cyclones that may hit the location of a solar plant financed by the FI in the next 10 years • Outputs can be given both as datasets and as thematic scores	• Expected damage in financial terms (e.g., USD) to the assets being modeled (e.g., power plants) • For example, annual average loss (AAL) in damage to a specific power plant in Odisha due to a Category 3 cyclone

Executive summary (5/6)

Chapter 4: Integration of risks into decision making

FIs can adopt a four-step approach, to disclose their climate related financial risks by reporting on four key areas - governance, strategy, risk management, and metric and targets. The figure below provides an overview of four steps, which draw from the disclosure areas specified by RBI, that FIs could follow as they considers embedding physical climate risks in their decision making.

Figure 4: Steps for integrating climate risk assessments, based on four disclosure areas

Prerequisite	1 Develop climate strategy	2 Establish governance	3 Implement changes (i.e., risk management)	4 Track progress (i.e., metrics and targets)
Conduct climate risk assessment – Overview	Develop a strategy to set the bank's vision for responding to a new climate reality. This will include establishing a plan based on baseline assumptions and considering multiple scenarios.	Ensure that the board has the required capabilities to push the climate agenda and to support management in implementing the climate strategy	Implement the required changes so that climate realities are included in the credit life cycle; provide a change management plan that supports the organization through the transition	Establish metrics and targets (targets are based on the objective of the assessment) and build systems to track progress on the goals determined
Conduct climate risk assessment – Sub-steps	1. Define the vision for climate-related activities 2. Stress test the strategy to ensure that it remains relevant across all eventualities	1. Support management in implementing the climate strategy 2. Ensure that the board has the required capabilities to oversee the climate transition	1. Integrate risk considerations into the credit risk cycle 2. Build a change management plan to ensure smooth integration and sustainable adoption	1. Develop a tracking framework 2. Implement a formal tracking system 3. Conduct periodic analyses and generate insights

Executive summary (6/6)

Way forward

Embedding physical climate risk assessment in the financial sector requires urgent collaborative action on key constraints. Three important gaps need to be addressed immediately:

1. Lack of reliable data for projecting climate hazards
2. Limited standardization and guidance on how physical climate risks can be translated into financial risks or loss metrics
3. Absence of macro-level action or guidance tying climate risk assessments to capital allocation decisions

Collaborative action is required between multiple stakeholders such as policymakers, regulators, financial institutions, and data providers.

Figure 5: Three focus areas for institutionalizing climate risk assessments across the ecosystem

Focus areas	Gaps	Action needed
Solve data gaps	The available climate-related hazards databases lack in granularity and standardization in terms of data collection metrics	**As a public good, build a platform for climate-related hazard data** and prescribe norms for collecting asset-level climate data
Understand climate-induced financial risks	Once a climate risk assessment has been conducted, more guidance is needed on how to convert physical climate risk into quantifiable financial risk	**Standardize methods for deriving financial risk** from physical climate risks
Address macro implications	Guidance is lacking on how to apply climate risk to capital allocation decisions[a]	**Standardize guidelines for applying climate considerations** to credit and capital decisions

CDRI, supported by RF is ideally positioned to facilitate a collaborative approach to develop solutions that can solve the challenges faced by the financial institutions. CDRI can work with the regulator, financial institutions, and other key stakeholders to help address gapes in the following ways:

- Enhance GIRI's capabilities such that it becomes the central repository for trusted climate hazard data and offers tools that are in line with FI needs
- Facilitate knowledge sharing and support with capacity building to build the ecosystem's understanding of key physical climate risk assessment concepts
- Share research and drive discussions on potential macro-level actions, policies and investment decisions

Introduction

Key Messages

1. Climate change is exacerbating natural hazards in LMICs, significantly increasing physical climate risks to critical infrastructure like power, telecom, transport, and buildings.

2. Climate-related losses to infrastructure assets pose financial risks to institutions with exposure, such as banks in India which hold over 30% of their outstanding credit in infrastructure portfolios.[1]

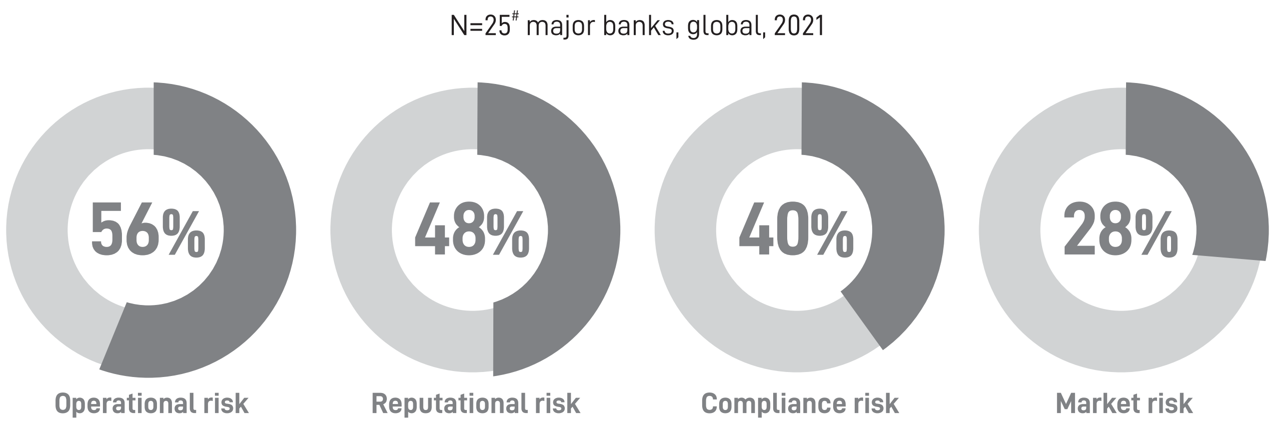
3. Financial sectors in LMICs are still in early stages of incorporating climate risks, and need actionable methods to assess asset-level physical risks. Enhancing climate risk understanding will allow better risk management by financial institutions and catalyze increased adaptation finance for vulnerable regions.

Introduction (1/2)

Low and middle income countries (LMICs) are among the most vulnerable to climate change, facing significant exposure to both physical and transition risks. The impacts of climate change pose serious threats to the populations, businesses, and economic stability of LMICs, while also influencing the decisions of investors, financial markets, and institutions. Physical risks stem from both chronic shifts in climate patterns (e.g., gradual temperature increases) and acute events like more frequent or severe storms, floods, droughts, and cyclones.

Financial institutions and systems are not immune to these risks, making the role of central banks and prudential supervisory authorities crucial in managing and mitigating their impact. Conducting physical climate risk assessments offers a structured way to identify, analyze, and evaluate these threats. Such assessments enhance the financial sector's resilience and open up avenues for climate adaptation finance, including solutions like insurance, catastrophe bonds, and other climate-resilient financial instruments. As destructive climate-related events increase in severity and frequency, damage to assets (and the attendant loss of revenue) can impact loan default rates, result in mispriced insurance products, reduce the value of collateral, and reduce potential exit prices for investors. FIs in India and around the world recognize the threat that physical climate risk poses to their business. For instance, a 2021 survey by KPMG indicated that 72% of global banks surveyed had identified climate change as a financial risk.[2] These risks are not limited to credit or financial risk; physical climate risk has risk implications across a bank's full suite of operations.

Figure 6: Proportion of banks that see climate risk as impacting other types of risk to the bank[3]



While financial institutions can engage in risk management, they can also offset risks by facilitating the development of more resilient infrastructure and opportunities in green finance. Building climate-resilient infrastructure requires CAPEX to fortify existing infrastructure and future-proofing new projects. The added costs can disincentivize their development.

#KPMG performed benchmarking of the climate-related disclosure of 25 major banks, consisting of 5 major banks in the UK, 5 banks in Europe, 4 banks in Australia, 5 banks in Canada and 6 banks in the US.

Introduction (2/2)

Low- and middle-income countries (LMICs) are among the most vulnerable to climate change, facing significant exposure to both physical and transition risks. Climate risk assessments provide a structured approach to identify, analyze, and evaluate these risks, ultimately informing more effective risk management strategies. This note specifically focuses on assessing acute physical climate risks associated with extreme weather events.

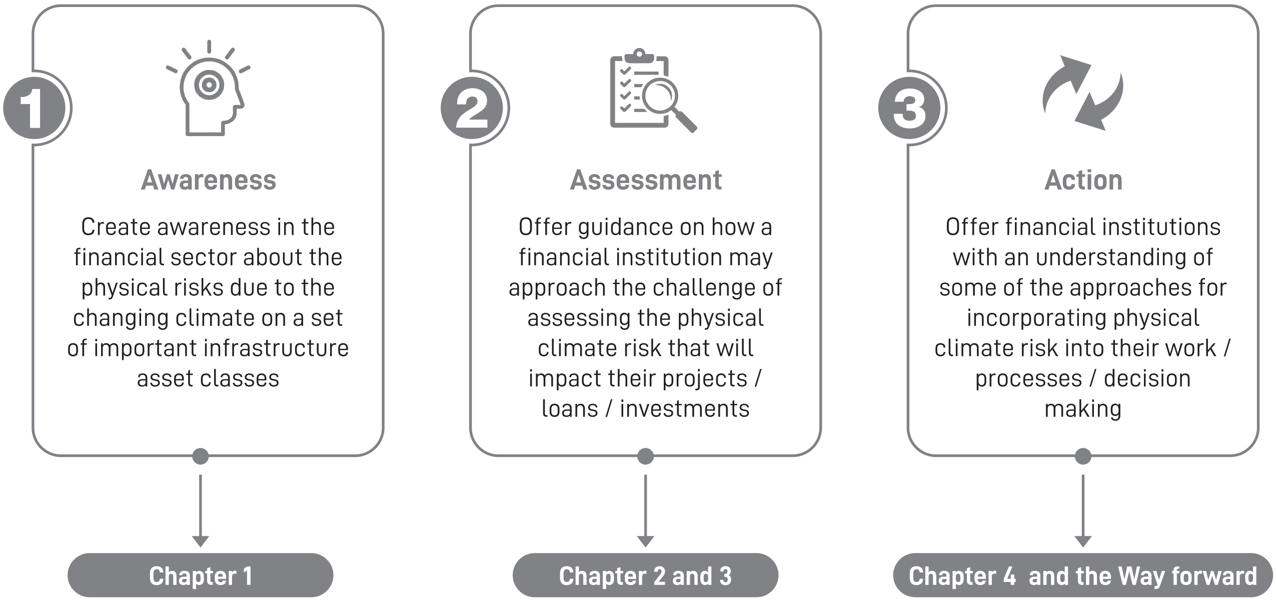
For LMICs, conducting such assessments presents unique challenges that can discourage authorities from pursuing them. Beyond the diverse climate risk profiles and economic conditions across these regions, the scarcity of reliable data and limited local technical capacity complicate the application of existing frameworks or leveraging the experiences of high-income countries.

Nevertheless, organizations like the World Bank have undertaken physical climate risk assessments in countries such as the Philippines, Indonesia, Morocco, Tunisia, and the West African region. These efforts highlight a crucial lesson: methodologies used in advanced economies are not always directly applicable to LMICs. Instead, these assessments must be tailored to account for each country's specific circumstances and data limitations..

Such an understanding will, over a longer term, catalyze an increase in financing toward regions that are most vulnerable to climate change and drive adaptation finance. A deeper understanding of climate risks will spur innovation in financial instruments specifically designed to hedge against such risks. This, in turn, will empower FIs to become more adept at channeling financing toward climate-vulnerable regions. Further, a better analysis and understanding of climate risks will, in the long term, lead to an increase in the level of finance available for adaptation. For example, World Resources Institute (WRI) mentions that measures to assess economic risk posed by climate change as well as measures to assess the financial and economic returns on investments designed to reduce those risks will both be needed to drive adaptation finance.[4]

The following chapters offer FIs a structured approach to understanding the physical climate risks posed by climate hazards. The document is not meant to provide the 'right way' to assess these physical climate risks. Rather, it is intended as a playbook of options for FIs looking to better understand the impact of physical climate risks, and to integrate this understanding into their business strategy going forward.

The playbook will cover three areas:



[4] https://www.ngfs.net/sites/default/files/media/2022/09/02/ngfs_physical_climate_risk_assessment.pdf

Chapter 1

Impacts of Physical Climate Risks on Critical Infrastructure and Financing Institutions

Key Messages

1. More than 90 percent of infrastructure around the world has been built in the last 50 years alone and about 60 percent of the infrastructure required by 2050 is yet to be built.

2. One-seventh of economic benefits generated from infrastructure assets in the past decades have been lost due to inadequate measures taken to make infrastructure assets and systems resilient (CDRI, 2023).

3. It is hence critical that financial institutions globally inform and facilitate government and private infrastructure investments to build and retrofit new and existing infrastructure to become climate and disaster-resilient. This will improve the fiscal appetite of infrastructure assets to absorb and adapt to disaster shocks and will enable them to achieve quick recovery and continued service delivery.

4. Various training programmes exist to build capacity and knowledge in this area. As an example, UNEP FI's Climate Risk and TCFD Programme aims to train representatives of financial institutions to "identify, measure, disclose and manage climate risk in the financial sector".

5. Compounding crises, such as natural hazards combined with economic downturns, increased financial strain, as seen with hurricanes and COVID-19 impacts in the Caribbean and Mexico. This underscores the need for integrated climate risk assessments in FIs, especially for LMICs which are at higher risk of simultaneous climate and macro-financial crises.

Context

Infrastructure is not just a fundamental piece in achieving economic growth but is also vital to achieving the Sustainable Development Goals (SDGs). More than 90 percent of infrastructure around the world has been built in the last 50 years alone and about 60 percent of the infrastructure required by 2050 is yet to be built[1]. It is estimated that the global infrastructure investment needed annually to address infrastructure deficits, achieve the SDGs, and achieve net zero by 2050 will be to the tune of US$ 9.2 trillion. Out of this, LMICs will require US$ 2.76 trillion – which is 30 percent of the annual total investment needed. This reinforces the need for financial institutions that understand climate and disaster risk to infrastructure assets and utilize them in funding of assets.

As climate change is impacting the intensity and frequency of hazards, existing infrastructure assets across the world are accumulating a large amount of physical climate risk. CDRI (2023) in its report expresses these physical damage risks stemming from climate change and other natural hazards in two metrics. The first is Total Exposed Value (TEV) which refers to the economic value of the infrastructure and the built environment, including social infrastructure at potential threat from being impacted by natural hazards, and the second is Average Annual Loss (AAL) which is the measure of annualized future loss estimates over the long term, derived from probabilistic risk models.

The global AAL figure for infrastructure sectors, including buildings, health and education infrastructure,

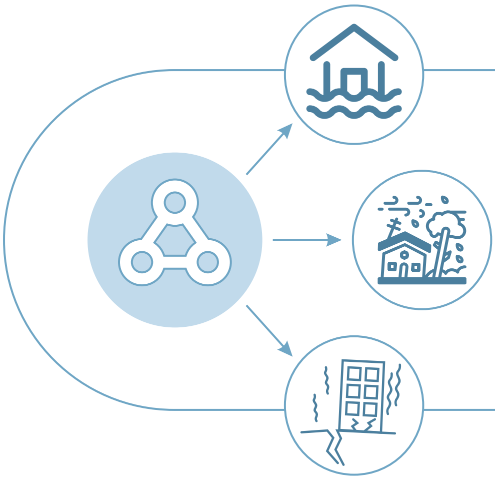
sums up to US$ 763 billion

as per current climate scenario, i.e. 14.6 percent of 2021-2022 GDP growth[2], while the global TEV figure is a whopping US$ 367.6 Trillion[3]

For all infrastructure sectors excluding buildings, the TEV value is US$ 186.24 trillion and the AAL value is US$ 301 billion. 70 percent of the Global AAL is contributed by climatic hazards including, "cyclonic wind, storm surge, flood, and rainfall-induced landslides" (CDRI, 2023, p.75), and the rest by "geological hazards such as earthquakes, tsunamis, and earthquake-induced landslides" (ibid). From a sectoral perspective, the AAL of the six infrastructure sectors amounts to US$ 301 billion. More specifically, the sectors such as roads and railways, telecommunication and power are most affected globally and they account for about 80 per cent of the global AAL of infrastructure across countries. The power sector is most vulnerable to floods. Wind impacts more than 50 percent of the oil & gas and ports & airports sectors. The roads & railways and water & wastewater sectors are most prone to landslides and earthquakes.

LMICs[4] account for 54 percent of global AAL amounting to US$ 397 billion although their share in global TEV is only 32.7 percent

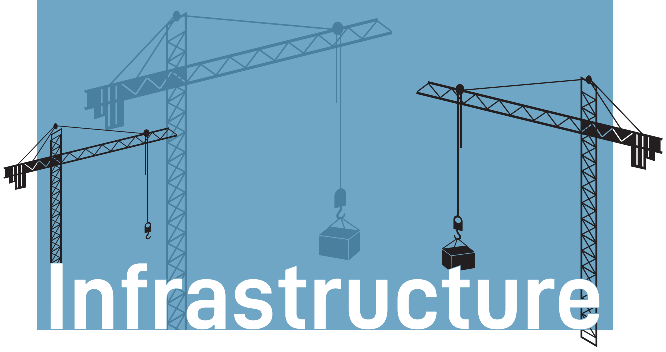
This is due to the fact that LMICs already lack adequate infrastructure compared to their richer counterparts. 37 (73 percent) out of 51[5] LMICs are situated in the three regions of East Asia and Pacific (12 countries), South Asia (6 countries) and Sub-Saharan Africa (19 countries). Global Infrastructure Risk Model and Resilience Index (GIRI)[6] data from 82[7] countries[8] in the above-mentioned regions reveal that these countries account for a little more than 50 percent of the global AAL amounting to about US$ 322.6 billion. The TEV for all infrastructure sectors in these regions is US$ 118.7 trillion.



The hazard with the largest share in the three regions' AAL is flooding followed by tropical cyclones and earthquakes. The primary hazard on average contributes to 74 percent of the AAL in these regions.

Apart from buildings which is the major sector needing intervention to reduce AAL, infrastructure sectors such as telecommunications, power, and roads and railways will require attention to significantly reduce AAL of the regions.

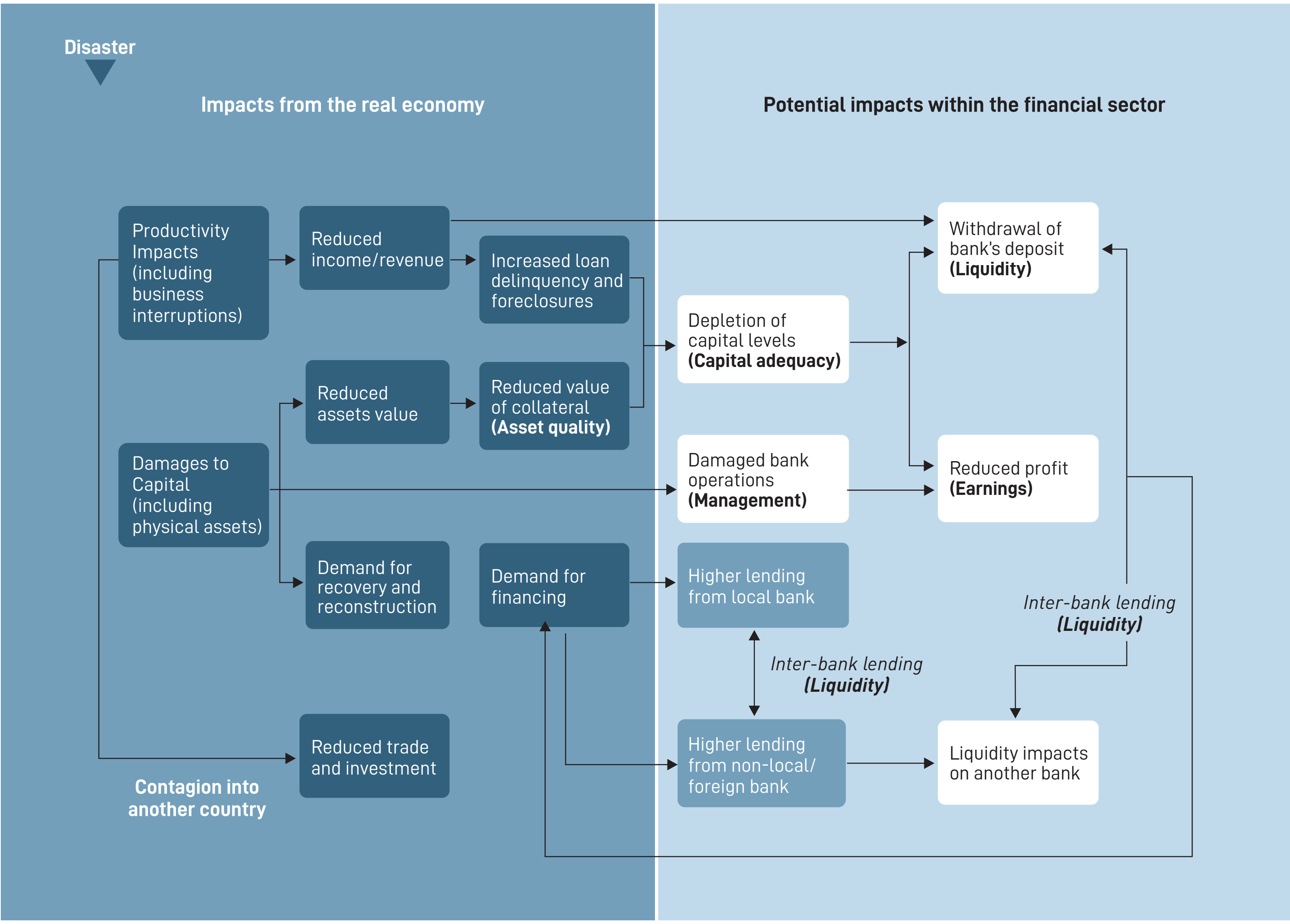
One-seventh of economic benefits generated from infrastructure assets in the past decades have been lost due to inadequate measures taken to make infrastructure assets and systems resilient (CDRI, 2023).



It is hence critical that financial institutions globally inform and facilitate government and private infrastructure investments to build and retrofit new and existing infrastructure to become climate and disaster resilient. This will improve the fiscal appetite of infrastructure assets to absorb and adapt to disaster shocks and will enable them to achieve quick recovery and continued service delivery. Investing in DRI will make the infrastructure lifecycle more sustainable resulting in substantial "resilience dividends" (CDRI, 2023, p.57). These dividends will not be visible in the short run but will become more substantial in the long run.

Why Financial Institutions (FIs) in LMICs must prioritize Physical Climate Risk Assessment

Illustration of the transmission channels for shocks from the real economy to the financial sector:



Source: World Bank[9]

In regions with strong pre-disaster financial resilience and a healthy banking sector, the financial impact of disasters tends to be minimized. Governments and central banks, even in developing countries, often act swiftly to stabilize the financial sector post-disaster. For instance, Nepal's central bank provided regulatory relief following the 2015 earthquake, while Thailand's central bank eased asset classifications after the 2011 floods. These interventions helped avoid major disruptions to financial stability.

However, financial stress is often more severe for local institutions and sectors serving vulnerable populations. During Typhoon Haiyan in the Philippines, local banks were significantly impacted, despite minimal national GDP effects. Similarly, Nepal's microfinance institutions faced challenges post-earthquake, highlighting climate-related risks in vulnerable financial subsectors. Small economies, especially small island developing states (SIDS), often face severe and prolonged impacts due to high vulnerability and limited recovery capacity.

Compounding crises, such as natural hazards combined with economic downturns, increased financial strain, as seen with hurricanes and COVID-19 impacts in the Caribbean and Mexico. This underscores the need for integrated climate risk assessments in FIs, especially for LMICs which are at higher risk of simultaneous climate and macro-financial crises.

State of affairs: how do financial institutions around the world take into account physical climate risks?

Physical climate risk assessment by investors and lenders is a relatively recent development. Most financial institutions have been focused on climate transition risks to date. The adoption of the recommendations issued by the Task Force on Climate-related Financial Disclosures (TCFD) set by the Financial Stability Board was instrumental in enticing financial institutions to undertake physical climate risk assessments. Various training programmes exist to build capacity and knowledge in this area. As an example, UNEP FI's Climate Risk and TCFD Programme aims to train representatives of financial institutions to "identify, measure, disclose and manage climate risk in the financial sector"[10].

Several Central Banks asked their domestic financial institutions to undertake climate stress tests to quantify the systemic risk posed by climate change. The Network for Greening the Financial System has developed various climate scenarios to inform such analysis[11].

Quantifying the impacts of physical climate risks on real assets and by extension on a portfolio of real asset investments and loans is not easy. Financial institutions need to determine a timeframe for this analysis and apply relevant metrics. Inputs from climate data and insurance firms are required to identify the climate hazard(s) that an asset may be exposed to and assess its vulnerability. There may be a range of outputs relating to different climate scenarios.

The most common analysis undertaken by financial institutions has centered on Climate Value at Risk, which typically incorporates the impacts of both transition and physical climate risks. This approach relies on an assessment of the probability of a hazard occurring and a range of severity. The potential loss at a specific location is linked to the capital expenditures spent on the asset and its expected EBITDA in any given year. This results in a percentage loss for the asset at a point in time in the future, both in terms of historic costs and operating cashflows. The methodology rarely considers the commercial and financial KPIs of the asset, such as penalties incurred under a concession agreement for extended periods of non-availability of a service or the circumstances under which the asset legal entity may breach its financial covenants. Nor does it focus on the reduction of vulnerabilities through the implementation of resilient measures and activities, and the associated value enhancement.

Selected financial institutions have been adopting complementary approaches to Climate VaR. The French infrastructure asset manager Meridiam publishes an annual TCFD report in which it refers to the implementation of the Climate Impact Analytics for Real Assets (CIARA) tool developed by Carbone 4[12]. This tool quantifies vulnerabilities via their impacts on Capex and Opex for each asset in the portfolio, based on an identification of material hazards.

The UK infrastructure fund Equitix uses a portfolio risk and vulnerability screening methodology that leads to a climate risk rating of its most vulnerable assets[13]. This approach is based on a methodology developed by the EBRD and the Global Center of Excellence on Climate Adaptation[14]. Separately, Multilateral Development Banks have been using a joint methodology for tracking climate change adaptation finance since 2022[15].

The Adaptation & Resilience Collaborative (ARIC), which is "an international partnership of development finance institutions working together to accelerate and scale up private investment in climate adaptation and resilience in developing countries" has recently issued an Investor Playbook on Physical Climate Risk Assessment and Management[16]. UNEP FI is the Secretariat for ARIC. The playbook includes a step-by-step approach to integrate physical climate risk assessment and management in the investment process.

In a forthcoming paper entitled "PCRAM for Investors", the Institutional Investors Group on Climate Change (IIGCC) highlights several challenges to the integration of physical climate risks in investment appraisal and real asset risk assessment, namely:

- An inconsistency across the different approaches for assessing physical climate risks
- A lack of standardization of the different physical climate risk disclosure regimes
- No prioritization of investments in asset resilience, which is often due to an uncoordinated approach among various decision-makers
- Different levels of sophistication and integration of physical climate risks among investors, with many of them seeking new frameworks and methodologies that create a link between the impacts of physical climate risks and asset valuations, including through the quantification and monetisation of resilience benefits

The so-called Physical Climate Risk Assessment Methodology (PCRAM) that was initially developed by the Coalition for Climate Resilient Investment and which is now embraced by IIGCC does make this link and can be seen as a milestone on the path towards a standardised approach to value enhancement through the reduction of an asset vulnerability to climate risks.

Similarly, in a document entitled "Mobilising Adaptation Finance to Build Resilience" published in October 2024, the Climate Financial Risk Forum in the UK is suggesting an Aim-Build-Contingency (ABC framework) be used to support decision-making under climate uncertainty[17]. This should be part of the development of adaptation-inclusive transition plans for financial institutions, which can be tailored to meet the different requirements of banks, asset managers, infrastructure asset managers and insurers.

More emphasis should be given to mitigating the impacts of physical climate risks: lenders should undertake systematic climate risk assessment as part of their due diligence, which could be labelled as extended ESIAs incorporating climate; financial investors should consider physical climate risk impacts not just as part of their investment appraisal and risk monitoring but also to assess an asset residual / exit value.

Channeling capital towards resilience is becoming critical. As noted in the "Guide for Adaptation Finance" issued by Standard Chartered, KPMG and the UNDRR in April 2024, there was a recognition at CoP28 in Dubai that "current levels of finance for adaptation are insufficient"[18]. This led to the creation of a Call for Collaboration to accelerate the mobilisation of private finance for adaptation and resilience. The Guide provides an "indicative list of financeable adaptation and resilience themes and activities, forming a classification framework"[19].

This is complemented by taxonomies, such as the Climate Bonds Initiative Resilience Taxonomy presented during New York Climate Week in September 2024[20]. Similarly, The Infrastructure Company Classification Standards (TICSS) developed by EDHECinfra "can be used to conduct sustainability and climate risk analyses of infrastructure equity and debt portfolios"[21].

Insurance is playing an increasingly important role in quantifying physical climate risks, developing frameworks for linking resilient investments with insurability and identifying optimal "tail risk" transfer points and solutions. Howden recently launched the Howden Resilience Laboratory with support from Microsoft to develop bespoke solutions to the climate-related needs of its clients[22].

The Resilient Planet Finance Lab of the Oxford University Environmental Change Institute has also made significant contributions to the advancement of knowledge and data availability in the field of climate adaptation and resilience, notably through its Resilient Planet Data Hub[23]. Making reliable climate data openly available is critical to ensuring that financial institutions have access to the information they require to take account of physical climate risks in their decision-making.

Chapter 2

Methodology for understanding financial institutions' exposure to physical climate risk

Key Messages

1. Regulatory requirements emphasize the importance of quantifying and disclosing climate-related risks for FIs, especially to equip them to make informed decisions.
2. Following a systematic assessment process for understanding physical climate risks can help FIs translate climate hazards into understandable risk metrics (e.g., climate value-at-risk) that can support decision making around risk management—including how to allocate resources efficiently and what mitigation measures to adopt.
3. FIs must look to diligently follow a four-phase process to undertake actionable, high-quality physical climate risk assessments:
    - **Define** the objectives of the assessment to ensure alignment with organizational goals and regulatory requirements.
    - **Convert** the objective into a clear scope, laying out the depth of assessment required and how it will be used for decision making.
    - **Assess** the hazard, exposure, and vulnerability of an asset to physical climate risks and translate these into a climate value-at-risk or thematic score to understand the overall risk level for the asset. This should further be translated into total exposure of the physical climate risk that the FI faces.
    - **Form** a holistic picture of physical climate risks by (i) interpreting the physical climate risk assessment in light of its underlying assumptions (e.g., bearing in mind how these assumptions ultimately place a limit on the accuracy of projections) and (ii) combining the assessment with other modeling and analyses.
4. FIs will also need to ensure that their objectives, models, and assessment evolve to keep pace with the dynamic nature of climate change. Furthermore, as FI capabilities increase, they should consider taking into account the compounding shocks of multiple (often interconnected) climate events.
5. Limited data availability (across hazard projections, exposure, and vulnerability) and lack of expertise within FIs to bridge this gap could be a key limitation. CDRI's GIRI platform—based on validated models and open source data—could be a helpful companion for FIs in navigating this space, given its facility at making hazard projections for standard scenarios. FIs can also look to an emerging set of private players employing proprietary methodologies.

Context

The previous chapter explored the physical climate risks faced by FIs. This chapter provides a process for FIs to understand and quantify the impact of these physical climate risks on their investments or exposure to an infrastructure asset. The process of quantifying these risks involves translating physical climate risk, which manifests through increasing frequency and severity of climate events (e.g., likelihood of occurrence of Category 5 cyclones), into financial risk. This could take the form of credit and market risk for FIs. Quantifying these risks will enable FIs to assess potential losses, allocate resources efficiently, prioritize their risk management efforts, and evaluate the effectiveness of mitigation or adaptation measures they might be planning to adopt. Regulatory requirements of various central banks across the globe, including RBI also emphasize the need for quantifying and disclosing climate-related risks.[1]

This process equips FIs with insights to make informed decisions. For successful implementation of physical climate risk assessments, it is crucial to secure buy-in from the board of directors and account for the concerns of investors. Quantifying these risks may result in increased costs, but it is a critical undertaking for the long-term resilience of the financial sector. The process can serve as the cornerstone for formulating proactive strategies aimed at mitigating and adapting to physical climate risks effectively, generating opportunities for green finance and sustainable investments. (Note: further details on how FIs may leverage these insights to improve their internal processes are provided in Chapter 4.)

Assessing physical climate risk requires a systematic evaluation of potential climate events and their repercussions for each asset. It is a multifaceted process that requires developing an understanding of potential climate events that can impact an infrastructure asset and the ensuing repercussions on an FI's investment in or project exposure to that asset. Scrutinizing these diverse hazards and their impacts can also help highlight any underlying vulnerabilities that FIs may carry in their infrastructure portfolios.

This chapter outlines an approach that FIs can follow to determine the physical climate risk associated with their exposure to any individual infrastructure asset. Physical climate risk for a bank is a function of the hazards faced by an asset, the exposure of the asset, and its overall vulnerability to the identified hazards. This chapter provides a step-by-step approach that leadership and risk teams at financial institutions can follow to develop a deeper understanding of how to quantify physical climate risk for an infrastructure asset.

Notes: (a) Buildings have been included here given significant exposure of FIs to the construction sector as well as exposure to housing finance; (b) Railways have not been considered for the analysis due to the financial sector's limited direct exposure to this sector. While the Indian Railway Finance Corporation (IRFC) is a financial institution with significant exposure to the sector, it could refer to the methodology laid out in Chapter 2 for guidance on assessing the impact of physical climate risks on the railways sector.

Process for measuring physical climate risk

Financial institutions can follow a four-phase process to assess the physical climate risk that stems from climate hazards. Figure below presents these phases; subsequent pages provide detailed guidance for each of the four phases.

Figure 7: Four phases of conducting physical climate risk assessment

Phase	Definition	How to implement (indicative – not exhaustive)
1 **Define the needs and objectives**	Lay the foundation for a successful risk assessment by setting clear goals that are aligned with organizational needs and priorities, as well as stakeholder expectations.	• Consult with key stakeholders (management, board, investors, regulator, subject experts, etc.) to understand objectives and expectations • Utilize available literature and risk indices to identify relevant hazards and vulnerabilities • Iterate on objectives as needed
2 **Set out the right-sized scope and approach**	Ensure that the risk assessment is tailored to maximize its relevance and effectiveness based on the organization's objectives and constraints.	• Consult with key stakeholders (management, board, investors, regulator, subject experts, etc.) to understand objectives and expectations • Utilize available literature and risk indices to identify relevant hazards and vulnerabilities • Iterate on objectives as needed
3 **Choose climate scenarios and estimate impact**	Select the appropriate scenario that reflects the organization's internal views on how the future climate will evolve. This can help FIs define the level of climate variance that needs to be accounted for.	• Select from standard scenarios (e.g., NGFS) that reflect—or construct a customized scenario that reflects—internal perspectives on climate change • Use the hazard-exposure-vulnerability framework to quantify the level of risk (covered in more detail in subsequent pages) that an FI could face, or undertake a thematic approach to form a qualitative perspective on the extent of damages from climate events • Consider including second-order damages and indirect impacts beyond direct losses, such as disruptions to infrastructure and shifts in investment patterns
4 **Present and interpret the results**	Present and interpret the results to facilitate climate-related decision making by stakeholders, ensuring that the findings are effectively communicated and utilized.	• Present quantitative and qualitative findings in a clear and accessible manner • Emphasize trends and orders of magnitude rather than precise numbers, to account for uncertainties • Communicate uncertainties, assumptions, and limitations to ensure informed decision making

Notes: (a) NGFS provides a comprehensive list of data required to conduct risk assessments in the document titled 'Physical Climate Risk Assessment: Practical Lessons for the Development of Climate Scenarios with Extreme Weather Events from Emerging Markets and Developing Economies." Available here: https://www.ngfs.net/sites/default/files/media/2022/09/02/ngfs_physical_climate_risk_assessment.pdf

Setting up climate risk assessment

Phase 1: *Define the needs and objectives*

Clarifying objectives is a fundamental step in ensuring that the analysis of physical climate risk is effective and aligned with an organization's goals. For an assessment of climate risk to be effective, FIs need to clearly outline the intended purpose of carrying out the exercise (e.g., enhancing the institution's risk management practices or fulfilling regulatory obligations), as well as how and where the assessment outputs will be used. The FI might, for example, intend to use the assessment to raise awareness internally about climate-related issues, update its internal risk models (e.g., updating the probability of default (PD) or loss given default (LGD) model for a bank), or ensure compliance with regulatory mandates. The figure below provides additional factors for FIs to consider when articulating the objectives of a physical climate risk exercise. Identifying regulatory requirements and stakeholder expectations—and articulating the organization's objectives in accommodating them—are crucial steps in determining what strategies the organization will employ throughout the rest of the assessment process.

Figure 8: Key factors to consider while defining the needs and objectives

Regulatory requirements and standards	Incorporate relevant regulatory requirements and industry standards into the defined objectives. Regulatory landscapes are evolving; financial institutions must stay compliant with emerging standards related to physical climate risk assessment and disclosure.
Stakeholder needs and expectations	Consider the diverse needs and expectations of stakeholders involved in or impacted by the investment. This includes shareholders, regulators, community members, and other parties. Aligning objectives with stakeholder interests ensures that the assessment remains relevant and meaningful.
Investment stage and desired outcome	Objectives should be tailored to the specific stage of the investment or project and the desired outcomes. For example, objectives may differ between initial scoping stages where a high-level risk identification is needed, or the due diligence stage where a more detailed assessment might be required to understand project viability.

Phase 2: *Set out the right-sized scope and approach*

Building on the defined objectives, the scope and depth of the assessment need to be determined while factoring in the FI's constraints (time, resources, budget, etc.). Defining the scope can provide clarity on the coverage of the risk assessment exercise (e.g., the type and intensity of hazards to be considered), as well as the depth of the assessment to be undertaken. For example, some situations may require a more detailed assessment of specific combinations of sector and hazard (e.g., a power generation project in a cyclone-prone area). These customizations are particularly relevant when dealing with specific business cases, such as lending to a highway project in a landslide-prone area or financing the construction of an agricultural warehouse in drought-prone regions. Capturing any required customization as part of the scoping phase can help FIs ensure that they judiciously employ resources and select the most appropriate solutions for conducting this assessment.

Estimate the FI's exposure to physical climate risk

Phase 3: Choose climate scenarios and estimate the impact

The market standard for estimating the impact of physical climate events utilizes the hazard-exposure-vulnerability (HEV) framework.[2] The HEV framework allows financial institutions to quantify the impact or risk associated with climate change by helping compute potential losses (the climate value at risk, i.e., climate VaR). Alternatively, the framework can help an FI determine a qualitative risk score by using a thematic approach. Regardless of the approach, the final step involves determining the share of the risk that can be apportioned to the financial institution. The figure below offers a step-by-step approach to using the HEV framework.

Figure 9: Overview of the hazard-exposure-vulnerability assessment model

Legend	Inputs	Outputs
Step 1	Aligning on climate scenarios	• Select appropriate scenarios that meet the needs of the organization and regulatory requirements • This will usually involve a range of scenarios that will typically include a most likely scenario and a worst-case scenario
Step 2	Hazard and Exposure	• Identify specific hazards (such as cyclones, floods, droughts, landslides, etc.) that may impact the asset based on its location and the chosen future climate scenario. • Assess the exposure of the asset to each identified hazard based on the frequency and severity of the projected climate events.
	Total climate exposure of an asset	
Step 3	Vulnerability	• Understand the likely loss of value to an infrastructure asset on account of its exposure to a climate hazard. This determination reflects the degree to which an infrastructure element is resilient to climate events and its ability to recover after the event.
Step 4	Projecting the level of climate risk	• Model an infrastructure asset's expected loss due to climate events, expressed in terms of climate value-at-risk. Alternatively, determine the risk based on a more qualitative, top-down approach (i.e., the thematic approach).
	Impact of climate events on an asset	
Step 5	Understanding risk in relation to the FI's total exposure	• Evaluate the expected impact on the financial institution by computing the exposure of the institution to that asset (i.e., what proportion of the climate risk is the financial institution exposed to).
	Total exposure financial institution faces to physical climate risk	

Method to estimate the impact of physical climate risk – deep dive on phase 3 (1/8)

Step 1: Aligning on climate scenarios

Choose the scenario that best aligns with the organization's perspective on how climate-related challenges will unfold. Since any estimate of loss related to physical climate risk depends on determining the extent of future climate hazards an asset might be exposed to, it is important to select an appropriate climate scenario. This scenario is obviously a significant factor in setting assumptions for how the frequency and severity of climate hazards might evolve over time. The choice of climate scenario should be guided by the organization's perspective on how climate-related changes will materialize (e.g., the expected temperature rise) as well as its objectives for climate scenario analysis (e.g., to assess loss under a likely scenario vs. to understand potential loss under an extreme scenario). This choice can have a significant bearing on the perceived risk attached to an asset. For instance, under a 1.5-degree-warming scenario, risks might be considerably lower compared to a 3-degree-warming scenario; however, it is important to note that even in the 1.5-degree scenario, the asset could still be subject to substantial losses, albeit likely less severe than the potential losses under the higher 3-degree warming scenario. While a range of well-established scenarios exist, each is based on several underlying assumptions, which a financial institution may further customize to align with its organizational views or suit specific needs (see box 1).

Box 1: Conducting scenario analysis

Financial institutions do not have to develop scenarios from scratch. Several well-established scenarios from authoritative bodies like the NGFS and IPCC exist. Nuance can be added to these by layering in different pathways such as the Representative Concentration Pathways (RCP) and Shared Socioeconomic Pathways (SSP). FIs can use these existing scenarios as they are or take them as foundations for the development of tailored scenarios for assessing the physical climate risks to an asset. This customization can include formulating an alternative view on how broader adaptation efforts play out and the likely impact on temperature rise, etc. Chapter 3 provides more detail on how an FI might integrate its own assumptions into an established climate change scenario.

Step 2: Calculating hazard and exposure

Assess the relevant climate hazards that are projected to impact the asset and then determine its potential losses due to those hazards. This step entails collating information regarding the likely frequency and severity of identified hazards that can affect the asset in the chosen climate scenario. The granularity or spatial resolution (e.g., state, district, PIN code, or a different grid) at which the FI seeks to collate this information can significantly impact the specificity and accuracy of the hazard and exposure assessment. In fact, the impact of a climate hazard can vary significantly even within a one-kilometer resolution. A cyclone, for example, is likely to impact an infrastructure asset located on a cliff on the coast more severely compared to a similar asset positioned further inland. The desired spatial resolution may be much smaller for hazards like floods.

However, FIs may need to make trade-offs between desired spatial resolution and available data on hazard events. While an increasing number of open-source models and private sector providers claim to provide these data, their capabilities vary in terms of offering high spatial resolution. Further, the built-in scenarios and assumptions that these models employ in projecting the likelihood of future climate events would need to be carefully evaluated. CDRI's GIRI model (currently available for two IPCC scenarios), which builds on open-source models, could be a starting point for obtaining hazard-related information for FIs (see more details at the end of this chapter).

Method to estimate the impact of physical climate risk – deep dive on phase 3 (2/8)

Step 3: Calculating vulnerability

Understand the asset's vulnerability, i.e., the likely degree of loss to due to climate-related events. The next step is determining an asset's vulnerability to the identified climate hazards it is exposed to. The vulnerability of an asset can be understood as its capacity to withstand a climate event or to respond to and recover rapidly from it. Figure below provides an overview of vulnerability of an asset.

Figure 10: Three Cs of asset vulnerability

The capacity to absorb	The ability to remain operational and perform well in the face of a climate event.
The capacity to respond	Should the capacity to absorb be overwhelmed and the asset operate below capacity (or not at all), the capacity to respond is the amount of time that the asset can operate sub-optimally after a climate event.
The capacity to recover	The ability to restore 100% capacity to perform operations / services, and the speed at which this restoration can take place.

Vulnerability of assets to physical climate risks can manifest in various ways, as described in the figure below.

Figure 11: Impact measurement for vulnerability

Impact on maintenance

- Climate hazards can require assets to build or buy resilience equipment (e.g., flood barriers), often at great cost
- Infrastructure deterioration due to climate effects leads to increased expenses for regular inspection, repairs, and replacements
- Climate-related wear and tear may also require significant expenditure on spare parts, further straining maintenance budgets
- Assets exposed to climate risks often incur higher insurance premiums, reflecting higher servicing costs

Impact on performance

- Climate-related disruptions to operations can result in suboptimal functioning or even temporary shutdowns
- Prolonged exposure to adverse climate conditions may render assets incapable of operating at peak efficiency, further reducing their value
- Such disruptions can lead to significant revenue losses and operational inefficiencies, affecting the asset's overall performance and value

Impact on life cycle

- Assets designed for a specific lifespan may deteriorate prematurely, due to frequent repairs and adaptations necessitated by climate events
- Fluctuations in market behavior, influenced by extreme climate events, can further impact asset valuations, affecting cash flows, capitalization rates, and financing options; for example, properties located in vulnerable areas like coastal regions may decline in value

Method to estimate the impact of physical climate risk – deep dive on phase 3 (3/8)

Estimate the asset's vulnerability by accounting for a complex interplay of factors. The vulnerability of an asset is contingent on multiple factors, including the asset's design and quality of construction, established maintenance practices, the preparedness of the asset's operators to respond to a climate hazard, and the quality of the surrounding infrastructure. For example, the vulnerability of a power plant in a flood event would be determined by the viability of the plant's response plan for that situation and its operators' ability to execute the plan rapidly (e.g., forward placing pumps to reduce inundation levels), as well as the availability of the surrounding road network (which might also be subjected to the flood) to ensure that critical supplies can reach the plant. Well-built assets with strong adaptation measures in place, manned by skilled operators, may be able to weather large climate events with minimal loss, while poorly built or underprepared assets can suffer catastrophic losses.

Both quantitative and qualitative techniques can help account for these factors in order to capture an asset's vulnerability. In LMICs, vulnerability assessments predominantly rely on qualitative data, due to lack of standardized practices and robust datasets (relative to more developed nations). Construction that follows stringent building codes can be reliably fed into a vulnerability model in developed nations where enforcement of such standards is high and can be easily verified. In contrast, such standards exist in LMICs but may not be regularly updated or enforced, and data on compliance with these standards are not readily available. For the LMIC market, therefore, qualitative assessments remain a key feature. However, FIs should attempt to create standardized models and incorporate quantitative techniques to the extent possible. GIRI incorporates some vulnerability assessment techniques that can serve as a resource or inspiration for FIs looking to further adapt these techniques in their own processes.

Box 2: Advancing physical climate risk vulnerability assessments

Vulnerability assessments focused on physical climate risks are a relatively new area of focus for FIs. While standardized practices and robust data may not be readily available, especially in certain markets, FIs can take an exploratory and iterative approach to refining their assessment frameworks over time. By collaborating with industry peers and research organizations, and drawing on regulatory guidance, institutions can work toward developing more sophisticated, data-driven models to evaluate climate-related vulnerabilities across their asset portfolios.

Step 4: Projecting the level of physical climate risk

Select one of two primary approaches to estimate climate impact: (1) a modeling approach that produces a climate value-at-risk or (2) a process that "scores" the asset on a relative risk scale. Table 1 illustrates these two techniques. The choice between these two approaches is a function of the objectives and scope laid out at the beginning of the risk assessment.

While these two approaches are distinct, the common practice is to combine them to form an integrated view of the impact of physical climate risk. For example, commercial banks with dedicated climate risk teams (or access to outside expertise on climate risk) may employ quantitative techniques to estimate hazard and exposure, but rely on qualitative scores to estimate vulnerability. Alternatively, a rating agency that assigns a qualitative risk score to an asset would likely include some quantitative modeling to bring robustness into their analysis.

Method to estimate the impact of physical climate risk – deep dive on phase 3 (4/8)

Table 1: Comparison of modeling approach and thematic approach

Aspect	VaR / modeling approach	Thematic approach
Definition	Estimates the future asset values based on climate event projections, utilizing advanced modeling techniques that integrate hazard, vulnerability, and exposure data as inputs; provides quantitative insights into potential financial losses	Assigns scores to projects based on the hazard, vulnerability, and exposure criteria related to climate risk; generally uses a framework of many metrics, each of which is assigned a score, with the final score calculated as a weighted average
Complexity and data requirements	Fairly complex, as it requires scenario specific climate data	Moderately complex due to reliance on historical data and simplified insights
Time and resource requirements	Requires significant time, expertise, and resources	Requires less time and fewer resources; offers a standardized approach for quick evaluations
Forward-looking and integration	Incorporates future climate scenarios and integrates with broader risk management framework	May incorporate future trends but less explicitly; serves as a standalone assessment
Actionability	Supports informed decision-making on risk mitigation strategies, offers flexibility to tailor assessments, and is comparable with other calculations	Provides initial guidance on areas of vulnerability; offers standardized approach for quick evaluations, but is not comparable with evaluations that use a different framework

Approach 1: Adopting the climate VaR approach

Choose from a diverse set of techniques that can integrate the hazard, vulnerability, and exposure components and align with overall risk assessment objectives. By employing probabilistic statistical models, climate VaR can provide FIs with a range of probable climate outcomes and associated losses, enabling them to quantify the likely loss that the asset could face. This approach offers actionable insights that are anchored in well defined assumptions, comparable across organizations, and can feed into effective risk management. Table 2 provides a non-exhaustive view of some of the techniques that can be used. Banks should choose one of these (or other) techniques based on cost and fit with overall risk assessment objectives (e.g., comprehensiveness and level of rigor required).

It is important to acknowledge that limitations on data availability (e.g., on hazard and exposure data) could impact the extent to which FIs are able to adopt this approach. As noted earlier, models like the GIRI could help FIs overcome these limitations (see Annex for a non-exhaustive list).

Method to estimate the impact of physical climate risk – deep dive on phase 3 (5/8)

Table 2: Comparison of various methods to conduct VaR analysis

	Scenario analysis	Probabilistic simulation model	Portfolio analysis
Definition	Uses statistical models to estimate the potential loss on an investment based on assumptions about the distribution of returns	Simulations are used to estimate the potential loss on an investment by generating a large number of possible future scenarios and calculating the expected distribution of loss across those scenarios	Provides analysis at a portfolio level to capture how risks interact with each other (e.g., benefits of diversification)
When is it most pplicable	Applicable when there is a need for a quick and relatively simple estimation of potential losses based on statistical models, particularly when assumptions about return distributions are readily available	Best utilized when a more comprehensive analysis of potential losses is required, especially in situations where the underlying probability distributions are complex or uncertain	Useful at the portfolio level, offering insights into how risks interact with each other and the potential benefits of diversification
Pros	Incorporates statistical modeling techniques to estimate risk, allowing for more sophisticated analysis and capturing nuances in the data distribution	Provides a comprehensive assessment of risk by considering a wide range of potential future scenarios; offers insights into the probability distribution of potential losses, allowing for more informed decision making	Allows for the assessment of risk across multiple assets within a portfolio; provides a straightforward approach to calculating risk metrics, such as VAR, based on the covariance matrix of asset returns
Cons	Highly dependent on the accuracy of the chosen statistical model and its underlying assumptions; inaccurate assumptions can lead to misleading results, especially in non-normal or volatile markets	Requires significant computational resources and time to generate a large number of simulations, making it computationally intensive; accuracy of results heavily depends on the quality of assumptions and inputs	Relies on the assumption of normal distribution, which may not accurately capture the true distribution of returns, given the uncertainty of climate change impacts; this can lead to underestimation or overestimation of risk

Method to estimate the impact of physical climate risk – deep dive on phase 3 (6/8)

Case study [1]: AXA Climate conducting the VaR approach for a large asset manager

AXA Climate is an AXA Group entity committed to addressing climate and environmental adaptation challenges. The company offers consulting services across various sectors to equip decision makers with science-backed, data-driven consulting services and software as a service (SaaS) tools to facilitate climate adaptation strategies.

AXA Climate partnered with a global infrastructure asset management (AM) firm to assess climate-related physical and transition risks within the AM's equity and debt portfolio. The objective was to align with International Financial Reporting Standards (IFRS) disclosure requirements to estimate material financial risks.

1. Selected relevant climate indicators and identified the **physical climate risks** for each asset covered in the screening; high risks implied higher materiality.

2. Assessed each risk to understand its **impact**(s) on the assets / sectors, and the evolution of the impact(s) over different climate scenarios and timeframes

3. Appraised the **financial materiality** of impact (CAPEX, OPEX, and revenues); prioritized 'most-at-risk' assets for implementation of adaptation response

AXA Climate began the assessment by gaining an understanding of the AM's exposure to physical climate risks through geospatial mapping of its global portfolio. This included identifying hazards, exposure, and vulnerabilities across key infrastructure projects worldwide. Subsequently, AXA Climate undertook stress testing of the portfolio over three (3) IPCC climate scenarios, spanning baseline, 2030, and 2050 timelines. All gathered data were then aggregated and modeled to estimate Value at Risk (VaR). AXA Climate was able to determine financial materiality by computing relevant indicators such as the impact on CAPEX, OPEX, and revenues. The process also facilitated compliance with country-specific disclosure requirements and provided insights for risk management prioritization. The collaboration empowered the AM to onboard internal stakeholders and integrate physical climate risks into governance, strategy, and risk management processes, and enabled the identification of the greatest climate-related threats to the AM's portfolio.

Method to estimate the impact of physical climate risk – deep dive on phase 3 (7/8)

Approach 2. Adopting the thematic approach

Develop a flexible approach to assigning qualitative risk scores to an asset—at the cost of potential nuance offered by a climate VaR approach, and with less applicability for risk management. FIs can develop a process to assign asset-level ratings by identifying indicators for different sub-components of the hazard-exposure-vulnerability framework, assigning qualitative ratings to each sub-component based on a well-defined scoring rubric, and aggregating these ratings into an overall risk rating for the asset. Such an approach can offer multiple possibilities to financial institutions to differentiate between risks (see case study 2), rate them based on an internal view of risk level, and combine these scores to form an overall rating. While this approach can offer valuable insights, they may not capture the full spectrum of physical climate risks, especially with regard to long-term climate trends, and may not easily lend themselves to assessment in terms of financial implications of climate hazards. Further, the non-standardized nature of such assessments could mean that climate scores may not be comparable across assets or time periods.

Case study [2]: Large private bank in India implementing a thematic approach to measuring climate risk

A large private bank in India adopted the thematic approach to climate risk assessment to begin taking physical climate risks into consideration in decision making.

The bank initiated the process by securing board buy-in to conduct climate risk assessments and appointed a climate champion to push the climate-risk agenda. It subsequently conducted a comprehensive internal assessment to understand its exposure to key physical climate risks through the development of a climate hazard map based on historical data. The mapping exercise enabled the bank to identify regions prone to risks and overlay its geographical spread to pinpoint areas of exposure. Subsequently, the bank categorized each loan and lending relationship based on an internal climate change risk rating to identify those with higher exposure to physical climate risks. The bank integrated this risk categorization into the credit preparation process, providing bankers with insights into the interaction of climate risk with their loans and facilitating the collection of pertinent credit factors. The bank is yet to incorporate physical climate risks into pricing or capital allocation, but aims to do so once it has gathered sufficient information and determines that the market is ready for this approach.

Deep dive on phase 3 (8/8), Phase 4: Present and interpret the results

Box 3: Thematic assessments: A steppingstone to a VaR approach

FIs should view thematic climate risk assessments as a crucial steppingstone toward more sophisticated, quantitative risk assessment methodologies. By first undertaking these thematic analyses, institutions can develop a deeper understanding of the data requirements, modeling approaches, and analytical frameworks needed to effectively incorporate climate risk modeling into their risk management practices. This foundational work will be instrumental in enhancing the sector's resilience to climate-related shocks and disruptions in the long term. Rather than viewing thematic assessments as a standalone exercise, institutions should leverage these initial forays into climate risk analysis as a springboard to building the necessary capabilities, data infrastructure, and modeling expertise required to ultimately adopt advanced techniques like value-at- risk (VaR) and other quantitative risk measurement tools. This stepwise approach will better position Fis to proactively manage the financial implications of a changing climate and ensure the long-term sustainability of their operations.

Step 5: Understanding the risk in relation to the FI's exposure

Evaluate the total exposure of the institution for that asset due to climate risk. The FI's overall exposure to an asset due to climate risk is a product of several factors, including the total volume of loans or other credit exposure outstanding to the asset as well as the de-risking structures that the FI has placed on the exposure. The latter can include aspects such as collateral, reporting requirements for loan monitoring, and the preparedness of the FI to respond effectively to a climate event.

Phase 4: Present and interpret the results

Facilitate climate-related decision making by stakeholders by ensuring that the findings are effectively communicated and utilized. Present findings in a clear and accessible manner, emphasizing trends and orders of magnitude rather than precise figures, and being sure to communicate uncertainties, assumptions, and limitations. Approaches such as climate VAR and thematic assessment provide a critical value or score that can help determine the overall level of risk for the asset. However, the VAR value or thematic score still rely on a number of assumptions that should factor into informed decision making.

Box 4: Sourcing data for undertaking VaR assessments

Many organizations currently lack the capacity to conduct an end-to-end VaR analysis. This is typically a function of some combination of resource constraints, lack of familiarity or expertise with climate-related VaR calculations, and limited data availability.

A rapidly evolving ecosystem of players can support FIs in conducting these assessments.

CDRI's GIRI model is intended to provide institutions with access to hazard and exposure data—for India and globally—that can serve as a credible companion to FIs when undertaking this exercise. Please refer to the spotlight at the end of this chapter for more details.

At the same time, many private sector firms now offer proprietary models that provide comprehensive assessments of climate-related risks to Fis. These include:

ClimateAi | Blue Sky Analytics | StepChange | auctusESG | AXA Climate

Additional considerations

1 Understanding the inter-related nature of physical climate risks

Climate hazards often interact with each other, amplifying their impacts and creating cascading effects across different sectors. For example, an increase in temperature can lead to more frequent and intense heat waves, exacerbating drought conditions and increasing the risk of wildfires. Similarly, rising sea levels can exacerbate the impact of storm surges, leading to more frequent and severe coastal flooding events. It is crucial to recognize the interconnected nature of climate risks and consider their cumulative effects when assessing vulnerabilities and designing adaptation strategies.

2 Periodical revision of climate risk assessments

Fis will need to continually revisit their climate risk assessments as the frequency and impact of climate-related hazards evolve over time. Costs associated with disaster response, recovery, and reconstruction efforts have noticeable increased in recent decades. Economic losses due to cyclones, for example, have surged in recent years, driven by factors such as population growth, urbanization, and climate change-induced sea level rise. These and other factors amplify the financial risks faced by institutions and emphasize that the calculation of climate VAR cannot be treated as a singular, isolated task. Instead, it must be regarded as an ongoing and recurrent necessity in the midst of evolving environmental conditions.

3 Avoiding individual bias

The effectiveness of both approaches relies heavily on the proficiency and accuracy of individual modelers or thematic reviewers. While expertise is integral to financial assessments, particularly in modeling scenarios, it exposes the sector to the risk of bias, groupthink, or undue influence. To avoid this dependence on individual capability, banks can consider forming a diverse team, documenting assumptions and methodologies transparently, seeking peer review, rigorously testing scenarios, and encouraging critical thinking to prevent biases.

4 Ensuring data quality and reliability

Fis must prioritize robust data practices. Both modeling and thematic approaches involve working with data sources that can be incomplete or inaccurate. Publicly available data and projections often fall short in terms of quality; vulnerability data, essential for accurate assessments, may be scarce and subjectively evaluated. While challenges exist, practical steps can be taken to improve accuracy. Ensuring transparent data sources, rigorous validation, and expert site visits can mitigate potential biases and inaccuracies. Acquiring data on hazards and exposure from reputable third-party vendors is a viable option; however, accessing more detailed and granular data entails increased costs. Banks must carefully weigh the expense against the desired depth of information when procuring data.

5 Considerations regarding standardization

While each approach employs a unique methodology for scoring and aggregating risk, it is essential for Fis to recognize and adopt industry best practices and standardized processes wherever possible, as lack of a common approach makes comparison difficult. For example, consider two different financial institutions employing thematic assessments to evaluate climate risk in their portfolios. Although the FIs aim to assess similar risks, the absence of standardized frameworks means that they might apply different scoring criteria, weighting schemes, or risk rating methodologies and assumptions, making direct comparisons challenging. Acknowledging this variability underscores the importance of standardized frameworks and regulatory oversight to enhance transparency and comparability within the industry.

Spotlight: Using GIRI to support climate risk assessments

Overview of the Global Infrastructure Risk Model and Resilience Index (GIRI)

GIRI is a first publicly available, fully probabilistic risk model for infrastructure assets with respect to critical geological and hydro-meteorological hazards, including climate risks. The following elements and capabilities of GIRI make it particularly valuable to FIs:

Based on hazard-exposure-vulnerability model	GIRI follows the same methodological framework described earlier in the playbook and is based on inputs of hazard, exposure, and vulnerability
Covers major sectors and climate hazards	GIRI highlights the likelihood of risks emerging from six key hazards (earthquakes, tsunamis, landslides, floods, cyclonic wind and storm surge, and hydrological drought) across critical infrastructure sectors (power and energy, transport, telecommunications, water, wastewater, ports and airports, oil and gas, health, and education)
Covers scenario analysis	GIRI also includes risks that are likely to emerge from two possible climate scenarios—Representative Concentration Pathway (RCP) 2.6 and 8.5

The platform can be accessed through this link https://giri.unepgrid.ch/

Uses of GIRI

GIRI could serve as a valuable tool to significantly assist in climate risk assessments. Possible use cases are highlighted below.

Before climate risk assessment	During climate risk assessment
GIRI can serve as a valuable preliminary tool for financial institutions to gain early insights into the regions and assets at risk. By utilizing GIRI, institutions can easily obtain a preliminary understanding of potential hazards and vulnerabilities across selected areas of investments.	GIRI's open-source nature offers additional advantages during the climate risk assessment process. The data and models utilized by GIRI can supplement and complement the risk models used by banks, thereby increasing the efficiency and effectiveness of the analysis.

Way forward

GIRI can serve as a valuable platform for the financial sector in understanding the extent of possible loss to infrastructure from physical climate risk. The industry needs a standard hazard data repository; GIRI's capabilities could evolve to support the current and future needs of its users. Specifically, CDRI and GIRI could provide additional value in two areas:

1. Provide granular risk projections: CDRI, in collaboration with ecosystem players (regulators, banks, others), could develop granular climate hazard projections for key climate risks relevant to LMICs and make them available in GIRI for open access. The entire ecosystem could refer to this dataset while analyzing physical climate risks
2. Serve as the base model for climate risk assessments: GIRI could evolve to include capabilities that allow FIs to leverage the data and modeling used in GIRI to build their own models. This could then serve as the base model for financial sector actors to customize based on their needs and objectives

Chapter 3

Deep dive on using scenarios to determine inputs for impact model

Key Messages

1. Climate scenarios play a crucial role in physical climate risk assessment, providing plausible representations of future climate conditions.
2. FIs should use widely recognized public climate scenarios and pathways, such as NGFS scenarios and IPCC RCPs, and should consider a range of scenarios to account for the evolving nature of climate change and ensure effective risk management.
3. Choosing a climate scenario is the first step in understanding the potential financial impact for FIs due to physical climate risk; climate scenarios offer a broad view of the future and typically do not provide a granular view of risks due to specific climate hazards such as floods or cyclones.
4. After choosing a scenario, FIs need to develop an internal hazard and exposure model to understand the physical climate risks that assets in their portfolio face.
5. Building an internal hazard and exposure model that quantifies risks to an asset is a complex activity that requires significant time, expenditure, and expertise; FIs should therefore consider collaborating with external organizations with expertise in undertaking climate and/or climate hazard modeling.
6. Alternatively, where expertise, budget, and/or data availability are lacking, FIs could consider developing a qualitative model that provides a view of the risk faced by an asset in the form of a thematic score (e.g., high, moderate, low). In this case, however, the FI will not be able to quantify the actual financial impact of physical climate risk on an asset.

Context

Climate scenarios are necessary resources for conducting physical climate risk assessments, but FIs also need more localized data. As discussed in the previous chapter, physical climate risk assessments need to be based on a carefully identified climate scenario. Established climate scenarios (e.g., IPCC) are intended to offer a broad view of how future climate may evolve globally. Weather conditions, however, are highly localized, and the impact of these conditions can significantly vary based on the location of an asset. To take an obvious example, an asset at the top of a hill is probably less vulnerable to floods than is an asset in a valley at the bottom of the same hill. To conduct risk assessments on specific assets, FIs need more localized information.

FIs can follow a three-step process to convert broad climate scenarios into useful, localized models that can help them ascertain the impact of physical climate risks on the asset. This three-step process is captured in Figure 12 below. In summary, FIs will first need to choose (and possibly modify) or develop a climate scenario with inputs that reflect the FI's view of future climate conditions. Second, FI's will need to ensure that these inputs are sufficiently granular to run internal hazard and exposure models that can provide an accurate picture of risk at the asset level. Finally, based on the asset's vulnerability and the FI's exposure to the asset, the expected impact on the asset will need to be determined. The execution of this process may vary in its depth based on the selected scenario (e.g., based on the extent of information the scenario provides as inputs for the localized model) but the overall process remains the same.

Figure 12: Three-step process for converting climate scenarios into a localized exposure model

	Step 1	Step 2	Step 3
Process	**Choose or develop the climate scenario for inputs (e.g., RCP 8.5)[a]**	**Leverage scenarios to develop internal hazard and exposure models[b]**	**Combine the inputs from the internal model with vulnerability and FI exposure to model impact for FIs[c]**
Objective	FIs need to understand how climate change may evolve in order to understand risk and make financial decisions. The scenarios reflect FIs view of future climate conditions (e.g., based on policy action, etc.), and allow them to test a range of potential pathways	The chosen scenarios (from Step 1) can provide a global / regional view of the climate situation, but need to be adapted to provide reliable inputs on specific hazards and exposure at a sufficient spatial and temporal resolution.	The outputs from the internal model developed in Step 2 will serve as inputs into the impact assessment model in Step 3. The outputs from the internal model will need to be combined with vulnerability data.
Inputs	• Inputs can include a range of hazards, global warming pathways, time horizons, etc. • Publicly available sources (e.g., RCP 8.5) could be used • Bespoke scenarios that reflect the • FIs views can be developed either internally or by hiring service providers	• Scenario(s) modeled in Step 1 • Geographically specific asset data and other information related to the asset. For example: Construction material, age, height and construction quality, etc. • Qualitative view of local climate conditions	• Hazard and exposure data modeled in Step 2 • Sectoral nuance • Vulnerability and FI exposure data
Outputs	• A range of hazard figures that reflect a view of expected climate outcomes • Best practice would include at least two scenarios (e.g., baseline case, worst case) so that a range of inputs can be tested across time frames	• Expected frequency and severity of relevant hazards at the desired spatial resolution specific to the transaction. • E.g., number and severity of tropical cyclones that may hit the location of a solar plant financed by the FI in the next 10 years • Outputs can be given both as datasets and as thematic scores	• Expected damage in financial terms (e.g., USD) to the assets being modeled (e.g., power plants) • For example, AAL in damage to a specific power plant in Odisha due to a category 3 cyclone

Notes: (a) Maps to step 1 of the framework in Chapter 2 for assessing climate risks; (b) maps to step 2 of the framework in Chapter 2 for assessing climate risks; (c) maps to steps 3, 4, and 5 of the framework in Chapter 2 for assessing climate risks.

Step 1 (1/2)

Step 1: Choosing and tailoring scenario(s)

FIs can select the appropriate scenario(s) based on a range of factors that can be grouped broadly into three categories. The choice of appropriate scenarios for physical climate risk assessment is pivotal, as it can significantly influence the need for depth in further analysis and impact the risk perception for the asset. FIs can select appropriate scenarios based on three broad criteria laid out in Figure 13.

Figure 13: Three criteria to select the appropriate scenario(s)

Acceptability of scenario

The scenario should be
- Widely adopted / referenced
- Data driven
- Transparent

Alignment with FI's perspectives

The scenario should
- Align with the FI's perspectives on the future
- Fit the FI's objectives (in terms of testing for a specific future)

Applicability to FI's need

The scenario should
- Cover relevant risks and geography
- Provide adequate geographic granularity
- Span the intended time horizon

\+ **Selected scenario**

FIs should consider a range of scenarios in order to account for the uncertainty associated with predicting future climate and the range of possible risks. FIs should consider at least two scenarios—typically a baseline scenario, reflecting the most likely future the FI anticipates, and a worst-case scenario, reflecting maximum impact or loss. In developing multiple scenarios, FIs can consider changing these inputs:

1 Global warming pathways

Explore diverse global warming pathways (e.g., NGFS scenarios, RCPs)

2 Time horizons

Consider various time horizons (e.g., 2030, 2050, 2100)

3 Event return periods

Incorporate different event return periods (e.g., 1-in-20-year event, 1-in-50-year event, 1-in-100-year event, 1-in-500-year event)

4 Hazards

Address a spectrum of hazards to cover a broad range of potential risks faced by the region or sector under assessment

Additionally, FIs should consider the impact of compounding shocks of multiple climate-related hazards occurring simultaneously, or of non-climate-related events that can exacerbate climate-related risk. Fis should appropriately account for the possibility and impact of multiple, simultaneous climate-related hazards (e.g., heavy precipitation followed by landslides, cyclones followed by coastal flooding, etc.) when developing the climate scenarios. The COVID-19 pandemic further demonstrated the importance of recognizing compound risk scenarios, wherein various climate-related hazards and other crises can occur simultaneously or in quick succession. These compounding events bring together economic, financial, environmental, and public health risks, and can lead to disproportionately large impacts. Neglecting these inter-linkages and their compounding effects can lead to underestimation of risk and hinder effective financial risk management.

Step 1 (2/2)

Current state of scenario development and application

Across LMICs, the most popular scenarios for assessing physical climate risk are the IPCC's Representative Concentration Pathways (RCP 8.5, RCP 2.6, and RCP 4.5), followed by the NGFS Hot House World scenario. Globally, the infrastructure sector is converging around RCP 8.5 as the "worst-case scenario," with the highest amount of CO_2 emissions in the absence of policy action. It is also a popular choice for a "baseline" scenario, as it assumes that no mitigation policies / measures are implemented. In a survey conducted by the Global Association of Risk Professionals, 26 out of 55 responding firms reported using RCP 8.5 as either their baseline scenario or as a downside scenario.

> **RCP 8.5 is not only the arguably most popular climate change scenario, it is also often framed in a very specific manner: as the business-as-usual trajectory that humanity is on if no climate change policies are adopted.**
>
> - Climate Matters,
> University of Hamburg

Box 5: Overview of RCP 8.5 Scenario by IPCC[1]

The RCP 8.5 combines assumptions about high population and relatively slow income growth with modest rates of technological change and energy intensity improvements, leading in the long term to high energy demand and GHG emissions in absence of climate change policies.

Time Horizon	Short term and long term (e.g., 2030, 2050, up to 2100)
Temperature rise	4.3 degrees temperature rise by 2100, relative to preindustrial levels
Outputs	The primary outputs include projections of changes in such climate variables as temperature, precipitation patterns, and sea levels
Geographical coverage	These climate data are available on a global grid and can often be downscaled to provide more detailed information for specific regions

As noted, this is a popular choice in the industry. However, such concentrated use of a particular scenario can also lead to some risks for the FI employing it. These include (1) a single point of failure in case of incorrect assumptions; (2) not adequately factoring in the views of those that may disagree with assumptions made in RCP 8.5; and (3) industry-wide overestimation or underestimation of future risks, leading to suboptimal decisions for risk management.

Climate scenario development has traditionally been dominated by international agencies, universities, and governments; however, a new wave of players is emerging that FIs may want to explore. These newcomers use innovative algorithms to optimize computational efficiency and accuracy, satellite data for geospatial analysis, and cloud-based infrastructure for distributed modeling and collaboration; they bring interdisciplinary expertise across climate science, data analytics, and policy. For example in India new players, such as CEEW, DST-IIT Delhi, and TERI, are able to provide dynamic, localized climate projections. For regulated entities, while the choice of scenario may be predominantly driven by established practices (or, alternatively, by regulation), these players could potentially help the FIs build more nuance and granularity into their scenarios.

Step 2 (1/2)

Step 2: Leveraging scenarios to develop an internal hazard and exposure model

FIs build upon the scenarios to develop models that provide a granular view of risks at an asset level. Scenarios typically provide projections of future CO_2 emissions / concentrations and the corresponding rise in global temperatures. Most scenarios typically do not provide a view on how these translate into projections of specific physical climate risks, such as floods, cyclones, or droughts. Further, the spatial resolution of the data is quite broad and does not provide an accurate view of the climate risks faced by specific localities, let alone specific assets. Non-localized analysis of climate risks are often an inaccurate indicator of the true risk faced by an asset—for example, while an asset may be located in a flood-prone district, it may be minimally impacted if it is located on higher ground or away from a body of water. Models built on top of these scenarios can aid FIs in translating the scenario inputs from Step 1 into an assessment of the hazard and exposure at the asset level. To be able to do so, the FI will need to feed two types of inputs into its internal model:

- **Downscaled local climate data.** FIs should aim to develop/access high spatial resolution data. This can be done either by downsizing the climate data from Step 1, preferably to the asset level, or by independently sourcing high-resolution spatial data from data providers.
- **Evaluation of an asset's immediate geography.** The model should also take into account the asset's immediate surroundings in the assessment of the risk that the asset faces (e.g., an asset located on a hill is at less risk of flooding than is one that is located in a low-lying area close to a river). This would typically be a predefined relative score that would be fed into the model by an individual after doing a site visit.

Building such models requires significant domain expertise, which FIs can seek outside of their organization. For instance, translating a scenario model from Step 1, which lacks hazard data, into projections for specific physical climate risks will require simulating extreme climate events (for example, hurricanes or floods) based on scientific models to produce an "event set," with indicators such as hazard frequency and intensity pertaining to the asset's geography. Due to lack of availability of granular public climate data, external data and modeling providers may provide expertise in developing such a database specifically for an FI's assets. Banks usually lack such capabilities, and building them is both time-intensive and costly. As a result, FIs should consider working with external vendors to develop such a model.

Alternatively, if budgetary or other constraints prevent building such models, FIs can adopt the qualitative approach of thematic scoring. A qualitative model is typically less granular and involves assigning a relative risk score (e.g., low, moderate, high) to a defined administrative / geographic unit—typically the district level—where the asset is located. This approach is relatively easier to develop and provides FIs with a simple way to understand which of their assets are the most at risk—and, consequently, an indication of how risky their portfolio is. However, a qualitative model does not allow for the quantification of risk in subsequent steps, and thereby restricts the FI's ability to understand how this risk may translate into losses for the asset, and what that may mean for the FI.

Step 2 (2/2)

Case study [3]: ClimateAi Translating data into models for actionable results

ClimateAi collaborated with an agricultural lender that was looking to develop a credit risk score based on water and climate insights.

Aligned with the client on the preferred climate scenarios and relevant inputs

Conducted thorough hazard and exposure analysis across the lender's portfolio; translated inputs into risk indices

Used risk indices to analyze portfolio risk and actions the client could take to reduce risk

ClimateAi aligned with the client on preferred climate scenarios and conducted an exhaustive analysis of hazard exposure across the lender's entire portfolio. Using advanced hydrological tools, ClimateAi translated the inputs into tangible impacts on supply chains, operational efficiency, and productivity across the lender's agricultural borrowers. Building upon this foundational analysis, ClimateAi devised a comprehensive water and climate stress index, incorporating insights from agricultural activities, industrial demand forecasts, and other relevant factors. This holistic approach allowed the lender to gain a granular understanding of the climate-related risks embedded within its portfolio, empowering it to engage with stakeholders more effectively, differentiate its financial services, and proactively manage climate-related risks in agricultural lending.

Step 3

Step 3: Combining the inputs from the internal hazard and exposure model with vulnerability to model impact for FIs

This step models the expected financial loss that an FI faces as a consequence of climate impacts on an asset. The modeling approach involves first combining inputs from the internal hazard and exposure model, such as the frequency and severity of the hazard that the asset is expected to face, with the asset's vulnerability to the hazard, to arrive at the expected damage / loss for the asset. The expected loss for the asset is then combined with the FI's exposure to the asset to arrive at the expected financial impact for the FI.

Financial institutions should try to adopt a step wise approach while building models to start where they can and initially focus on portfolio-level assessments to gauge risks in their existing assets. As they progress, they can adopt metrics like Probable Maximum Loss (PML) and Tail Value at Risk (TVaR) to evaluate potential worst-case scenario losses. Additionally, implementing a marginal risk assessment process will aid in making informed underwriting decisions for new assets.

Chapter 2 provides detailed guidance on how to use the vulnerability model and the FI's impact model.

Chapter 4

Integration of risks into decision making

Key Messages

1. The global financial sector is adapting to the challenges posed by climate change. Regulators are emphasizing the need to integrate climate risks (including physical climate risks) into banks' decision making.

2. Draft climate change disclosure guidelines from the regulator include four core disclosure areas — governance, strategy, risk management, and metrics and targets — that align with international standards.
   - **Strategy:** Developing a robust climate strategy is paramount for banks to navigate the challenges and opportunities presented by climate change. The disclosure requirements mandate that banks articulate a vision for climate-related activities, identify strategic areas of engagement, and devise strategies for climate integration. By stress testing their strategies across various climate scenarios and time horizons, banks can enhance their resilience and effectively address evolving climate risks.
   - **Governance:** Establishing robust governance around climate risk can foster accountability and proactive management within banks. Boards can take a proactive role in supporting the bank's management team in crafting and implementing the climate strategy. At the same time, banks should ensure that the board possesses the capabilities to oversee the transition.
   - **Risk management:** Banks must embed climate considerations throughout the credit life cycle. This represents a fundamental shift in operational mindset for banks, which will require a structured change management plan to overcome internal resistance and ensure successful adoption.
   - **Metrics and targets:** By setting measurable targets and implementing a formal tracking system, banks can monitor efforts, assess performance, and adapt strategies accordingly. This approach ensures that compliance with regulatory requirements is traceable, enhances risk management practices, and improves decision-making processes for addressing climate-related challenges.

3. Apart from risks, climate change also presents opportunities for banks and other financial institutions to drive green transition by supporting climate resilience, financing businesses in new climate conditions, and facilitating the transition to a low-carbon economy. However, the green finance market is still nascent in most LMICs; government support is crucial if this market is to thrive.

Context

Reflecting the new climate reality, the global financial sector is integrating climate risks into its operations. Regulators across key markets, including Canada and the Eurozone (including France, Germany, and the Netherlands), have conducted and published the results of their initial climate risk analyses. These regulators and others (e.g., Hong Kong, Singapore, Spain, and the United Kingdom) are issuing, or planning to issue, expectations for banks to disclose, manage, and integrate climate-related risks into their operations.[1] These requirements are often based on the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD),[a] reflecting a global commitment to transparency and accountability in a changing climate.

- **Governance:** Defining the organization's governance around climate-related risks and opportunities
- **Strategy:** Incorporating the actual and potential impacts of climate-related risks and opportunities on the organization's businesses and financial planning
- **Risk management:** How the organization identifies, assesses, manages, and prioritizes climate-related risks
- **Metrics and targets:** The metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material

This chapter builds on an understanding of physical climate risks developed in previous chapters to offer practical guidance on how a bank can incorporate these risks into its operations. It provides a step-by-step process for acting across the four disclosure areas highlighted by the regulator.

It is important to note that conducting the climate risk assessment a prerequisite to executing these steps. Once the climate risk assessment is complete, FIs need to determine how to integrate this assessment into decision making. The four steps described in Figure 14 offers a framework.

Figure 14: Steps for integrating climate risk assessments, based on four disclosure areas

Prerequisite: Conduct climate risk assessment	1 Develop climate strategy	2 Establish governance	3 Implement changes (i.e., risk management)	4 Track progress (i.e., metrics and targets)
Overview	Develop a strategy to set the vision for responding to a new climate reality. This will include establishing a plan based on baseline assumptions and considering multiple scenarios	Ensure that the board has the required capabilities to push the climate agenda and to support management in implementing the climate strategy	Implement the required changes so that climate realities are included in the credit life cycle; provide a change management plan that supports the organization through the transition	Establish metrics and targets (targets are based on the objective of the assessment) and build systems to track progress on the goals determined
Sub-steps	1. Define the vision for climate-related activities 2. Stress test the strategy to ensure that it remains relevant across all eventualities	1. Support management in implementing the climate strategy 2. Ensure that the board has the required capabilities to oversee the climate transition	1. Integrate risk considerations into the credit risk cycle 2. Build a change management plan to ensure smooth integration and sustainable adoption	1. Develop a tracking framework 2. Implement a formal tracking system 3. Conduct periodic analyses and generate insights

Box 6: Note to reader: The difference between disclosure requirements and playbook recommendations

This playbook is more than a list of RBI disclosure requirements. It explains what these disclosures require of financial institutions and offers step-by-step guidance on how FIs can meet these requirements within their existing systems.

Note: (a) The Financial Stability Board has announced that the work of the TCFD has been completed, with the ISSB's Standards marking the 'culmination of the work of the TCFD'.

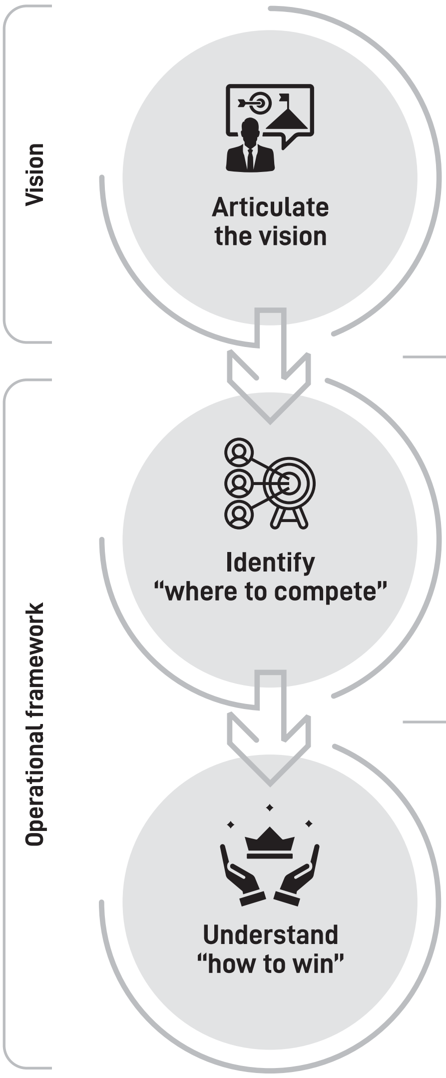
Step 1 – Developing climate strategy (1/2)

All FIs should build a robust climate strategy to guide their decision making around tackling the climate challenge. Draft regulatory guidelines require the bank to disclose the following aspects of its climate strategy:

- The identified risks and opportunities over the short, long, and medium term
- The impact of climate-related risks and opportunities on the business and financial planning
- The resilience of its climate strategy considering different scenarios

Undertaking a climate risk assessment that includes a physical climate risk assessment, as laid out in previous chapters, is a key input in the strategy. The strategy should also outline the bank's approach to proactively managing these climate risks and capitalizing on opportunities arising from the transition to a low carbon economy (e.g., green financing for infrastructure). The following graphic highlights the steps banks can take to craft such a strategy:

Sub-step 1: Define the vision for climate-related activities



- Articulate a clear vision statement defining the bank's long-term goals for integrating climate risks. This vision should encompass navigating climate challenges, capitalizing on opportunities, and achieving a sustainable and resilient future state.
- Recognize the evolving nature of climate risks and ensure that the vision statement remains adaptable. Encourage ongoing refinement and seek board's input to reflect the bank's strategic direction.

- Identify strategic areas for engagement based on the results of the risk assessment, focusing on products, geographies, sectors, and client segments
- Ensure alignment of strategic areas with the bank's natural or historical strengths to leverage existing capabilities for enhanced climate resilience and market competitiveness

- Define a winning strategy by establishing a set of exercises to repeat periodically in order to reinforce and expand the bank's climate position
- Delineate programs, products, and risk management frameworks to mitigate climate-related risks and identify avenues for sustainable growth, strengthening climate resilience and seizing green growth opportunities

Step 1 – Developing climate strategy (2/2)

Sub-step 2: Stress test the strategy to ensure that it remains relevant across all eventualities

The strategy should ensure adaptability and effectiveness in addressing evolving climate risks. The strategy should adopt a forward-looking stance, considering not only the immediate but also the medium- and long-term impacts of climate change. Additionally, it must remain resilient across a spectrum of potential climate scenarios, preparing the organization for the uncertainties of potential climate futures.

Understanding the strategy for various climate scenarios

- Conduct scenario planning to assess the potential impacts of different climate scenarios on the bank's operations and objectives
- Gain insights into vulnerabilities and opportunities by considering a range of potential climate scenarios

Devising strategies for different scenarios across varying time horizons

- Develop tailored strategies for addressing different climate scenarios across short-term, medium-term, and long-term (time) horizons.
- Align objectives with anticipated impacts of climate change to proactively plan and allocate resources.

Developing such a climate strategy can require considerable effort. FIs can begin the journey of crafting a compelling climate strategy with two initial action items:

Elevating climate awareness

If a clear climate strategy is not yet in place, starting discussions about climate risk with senior management sets a critical foundation. Including climate on senior leadership meeting agendas and communicating the need for action throughout the organization fosters awareness and opens the door for further action.

Developing climate scenario planning

Developing sophisticated internal climate modeling might be a long-term goal. However, even without such models, exploring potential climate scenarios is a valuable first step. By considering how the bank's strategy might need to adapt under different climate conditions, the organization can begin building resilience and identify early opportunities.

Step 2 – Establishing governance (1/3)

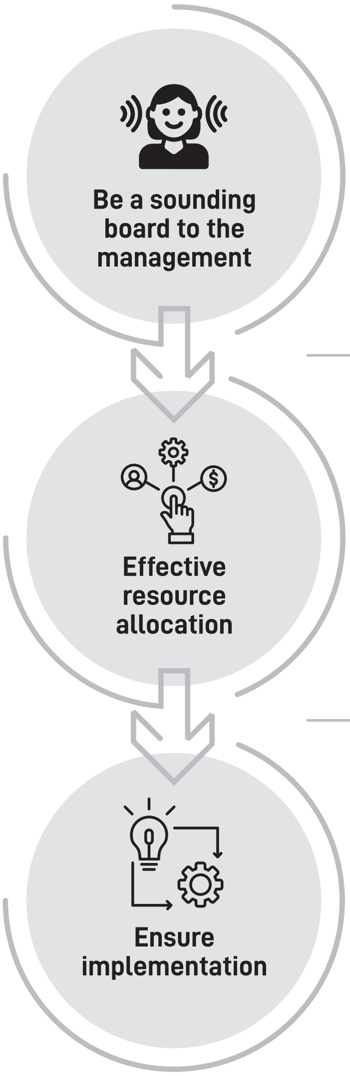
Establishing robust governance around climate risks can create a culture of accountability and proactive management that allows the bank to stay true to its climate strategy and commitments. Clear lines of accountability and responsibility can ensure that climate risks are considered in strategic decision-making processes and management is held accountable for its decisions. Draft regulatory guidelines require banks to disclose:

- The board's oversight of climate-related risks and opportunities
- Senior management's role in assessing and managing climate-related risks and opportunities

To create that culture of accountability and benefit from the integration of climate-related risk assessments, banks should consider making their board the climate champions of their organization. With the right resources, the board can support management in climate risk integration. This is explored in greater detail below.

Sub-step 1: Support the management team in implementing the climate strategy

The board can play a pivotal role in shaping the climate strategy. By offering diverse insights and perspectives, the board can further enrich the strategy and inform the management team's decisions. To be an effective partner to management, the board should undertake the following steps:



Be a sounding board to the management

- Go beyond endorsement to serve as an agent that can refine the strategy by surfacing unconventional opportunities
- Bring diverse decision-making perspectives to critically test assumptions and catalyze an evaluation of alternative approaches

Effective resource allocation

- Allocate financial resources to essential tools, data platforms, and infrastructure for effective climate strategy implementation
- Invest in cutting-edge technologies such as predictive modeling software and climate data visualization tools to aid informed decision-making
- Bolster the team with climate expertise through targeted recruitment or staff training to ensure effective climate risk management

Ensure implementation

- Establish clear measures for executing the climate strategy, including implementing reporting conditions to track progress and ensure transparency in decision-making processes
- Consider incentivizing successful execution of the strategy by tying performance-linked bonuses to key climate-related objectives, motivating proactive management of climate risks and opportunities

Step 2 – Establishing governance (2/3)

Sub-step 2: Ensure that the board has the required capabilities to oversee the climate transition

FIs can support the board with the right information and resources by taking the following actions:

Establish a climate governance committee

- Form a specialized committee within the board dedicated to guiding the organization's climate agenda, ensuring that climate issues are discussed at the highest level
- Ensure that the committee is the central coordinating unit to guide the board's thinking on climate issues and oversee the integration of climate considerations into strategic decision-making processes

Enhance board capacity

- Conduct comprehensive training sessions for board members to enhance their understanding of and proficiency in addressing climate risks and opportunities, ensuring that they are well equipped to guide the organization effectively
- Appoint a climate specialist to provide the board with targeted expertise and insights, thereby enhancing the board's ability to oversee climate-related transitions with agility and foresight

Foster access to pertinent data and expertise

- Establish mechanisms to provide the board with access to reliable data and expert counsel from both internal reporting channels and external sources, facilitating informed decision-making on climate-related matters
- Foster a robust informational foundation for the board, enabling it to navigate the intricate landscape of climate-related risks and opportunities with confidence and clarity, thereby supporting strategic responses aligned with the organization's objectives and values

Together, these two steps—supporting the management team's implementation and ensuring the board's oversight capacity—will help banks clearly establish robust governance and take the next steps in integrating climate risk assessments into their operations. Banks can take two immediate next steps:

Appoint a climate champion

Designate an individual within the board to serve as the primary point of contact for climate-related initiatives. This appointed champion will spearhead the advancement of the climate agenda, leveraging their deep subject matter expertise to drive meaningful progress and foster a culture of climate resilience within the organization.

Initiate essential data collection

Kick-start the process of collecting data points relevant to climate-related financial risk. These data will be critical to informed decision-making and strategic planning in alignment with climate objectives.

Step 2 – Establishing governance (3/3)

Case study [4]: CBI anchored India Initiative on Climate Risks and Sustainable Finance (IICRSF), conducting capacity building for banks

Climate Bonds INITIATIVE

The Climate Bonds Initiative (CBI) is an international organization dedicated to mobilizing global capital for climate action. It achieves this through the development of the Climate Bonds Standard and Certification Scheme, as well as through policy engagement and market intelligence services. The organization empowers its partner organizations with the tools and knowledge needed to navigate, influence, and instigate change to tackle climate-related risks.

IICRSF, a collaborative anchored by Climate Bonds Initiative with partners auctusESG and ODI, aims to support policy makers, regulators, financial sector, and corporate entities with know-how on climate risks, disclosures, transition plans, and transition finance. IICRSF focuses on enhancing banks' capacity (at board, senior management, and middle management levels) to understand and integrate climate risks and opportunities into their operations. To address the growing significance of climate-related factors in financial risk management, IICRSF took these three steps:

CBI developed tailored training modules that focused on fundamental climate change concepts, the importance of climate risk assessment, net zero banking, and practical approaches for integration (with case examples). The organization delivered these modules via workshops conducted for banks' credit risk departments and board members, to facilitate in-depth discussions on emerging climate risks and their implications on the lending life cycle. CBI organized these workshops as individualized, capacity-building exercises, ensuring that banks received targeted knowledge based on their specific needs and challenges.

Step 3: Implement changes (1/4)

As banks prepare to make disclosures about their climate risk management, they can improve their risk management practices by incorporating a set of considerations across the credit life cycle. Banks must build capabilities and processes to comply with draft regulatory guidelines that require them to disclose the following:

- Processes for identifying, assessing, prioritizing, and monitoring climate-related financial risks
- Processes for managing climate-related risks
- A description of how these processes are integrated into the organization's overall risk management strategy / processes

However, taking a more considered and nuanced approach to incorporating climate risk throughout the credit lifecycle can help a bank meet these disclosure requirements while also fundamentally changing how it insulates itself against climate risks. Figure 15 lays out these considerations below.

Figure 15: Climate considerations across the credit life cycle

Credit life cycle →

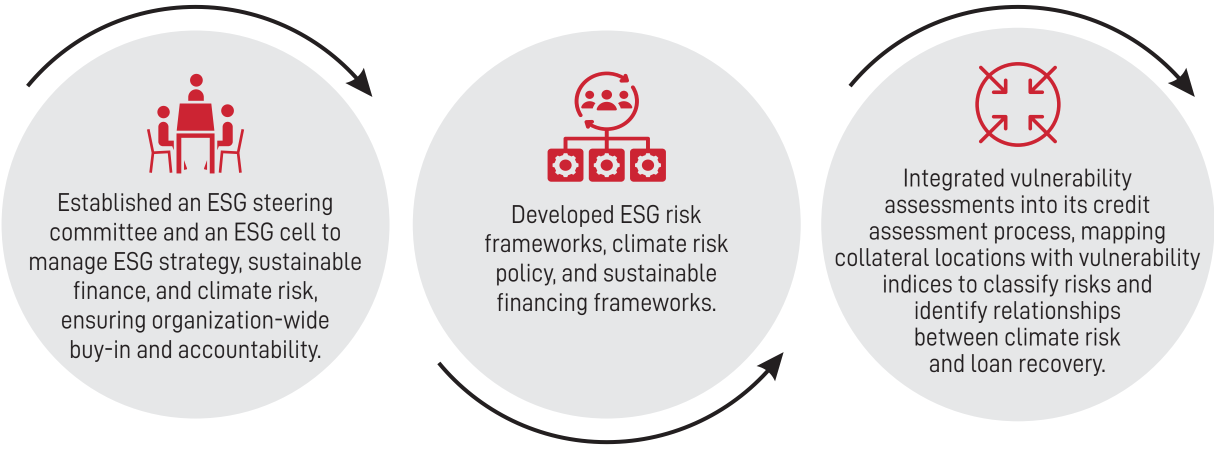
	Prospecting and origination	Underwriting and approval	Collateral management	Monitoring and portfolio management	Default management
Overview	Identify potential clients, initiate new relationships, and assess creditworthiness and suitability for lending	Evaluate the credit risk, determine loan terms and conditions, and obtain approval for extending credit	Assess and manage assets provided as security for loans; ensure that they adequately cover the loan amount in case of default	Track repayment performance (PD/ LGD), identify early warning signals of financial distress, and manage the overall portfolio risk	Identify losses, restructure repayment terms, and manage recoveries
Climate consideration	Target climate friendly sectors and institutions; consider industry specific climate vulnerabilities	Consider climate factors for underwriting and rating; adjust loan terms based on identified climate risks	Utilize insurance or other risk transfer mechanisms to mitigate potential losses associated with climate-related impacts on collateral assets	Assess changes in risk profiles and adjust portfolio strategies to mitigate climate-related risks	Assess the impact of climate on loss realization and incorporate these data into credit risk appraisals

Step 3: Implement changes (2/4)

Case study [5]: Union Bank of India incorporates climate risks into its decision making

Union Bank of India, a leading public sector bank headquartered in Mumbai, has 8,700+ branches, 11,000+ ATMs, and serves over 161 million customers. It has been one of the pioneers within the Indian ecosystem of integrating climate risks into decision-making processes.

Union Bank adopted a strategic approach to integrate climate risks into its decision making, emphasizing the establishment of governance structures and the formulation of comprehensive climate risk frameworks.



Union Bank of India initiated its climate risk integration journey by setting up robust governance structures, including an ESG steering committee and a dedicated ESG cell, to oversee the development and implementation of its ESG strategy and climate risk management processes. Subsequently, the bank developed a suite of climate risk policies and frameworks, such as the ESG Risk Framework and Climate Risk Policy, to provide guidance and direction for risk management activities. Additionally, the bank incorporated climate risk analysis into its decision-making processes by integrating vulnerability assessments into its credit assessment process and employing an integrated climate risk management solution. By mapping geographical data of collateral against vulnerability indices and sector-specific risk factors, the bank analyzed the relationship between climate risk and loan recovery rates. This proactive approach helped the bank draw insights to strengthen its lending practices, enhance risk management capabilities, and also set a precedent for the industry.

Step 3: Implement changes (3/4)

Incorporating these steps requires banks to develop and follow a robust change management plan. The transition to climate risk management requires a significant shift in organizational practices, policies, and culture. Following a structured approach can ensure that banks are able to comprehensively execute different dimensions of change management, bring along the entire organization in recognizing the importance of this exercise, and manage any internal resistance to change. In contrast, not doing so can lead to stalled progress or sub-optimal implementation of climate risk practices. A change management plan might follow these five essential steps:

1

- **Preparing for change:** Conduct thorough assessments of current lending practices to identify and demonstrate climate vulnerabilities; inform employees about the impacts of climate risk on lending operations and develop a vision for change
- **Key considerations:** Account for the unique characteristics of the bank's portfolio—such as geographic locations, industry sectors, and asset classes—and tailor communication strategies to different audiences within the organization, highlighting the relevance and implications of climate risk management to their specific roles

2

- **Designing the change:** Set up a cross-functional team comprising experts from various departments to design the new risk management processes, policies, specific metrics, guidelines, and operating procedures
- **Key considerations:** Incorporate feedback from frontline lending staff to ensure that new processes are practical, user-friendly, and aligned with their day-to-day responsibilities; consider bringing in external expertise to supplement internal capabilities and knowledge in designing robust risk management frameworks

3

- **Implementing the change:** Roll out training programmes to educate lending staff about applying climate risk management principles to their day-to-day tasks, update loan origination systems and risk assessment tools, and pilot new lending processes
- **Key considerations:** Customize training materials and sessions to address the varying levels of knowledge and expertise among lending staff; establish clear communication channels for sharing feedback and best practices among different teams and departments involved in the implementation process

4

- **Adapting the change:** Gather feedback from lending staff and clients about the effectiveness and usability of the new processes; make adjustments and iterative improvements as necessary
- **Key considerations:** Recognize and reward suggestions for process enhancements from frontline staff, prioritize feedback that aligns with the bank's immediate strategic objectives and climate risk management priorities, and build trust with stakeholders by communicating transparently about ongoing changes

5

- **Sustaining the change:** Embed best practices into the bank's official lending processes, provide ongoing training and support to lending staff, and review policies and procedures regularly to reflect evolving regulatory and market requirements
- **Key considerations:** Foster a culture of accountability and ownership among staff by establishing clear roles, responsibilities, and performance expectations related to climate risk management; monitor key performance metrics to track the effectiveness of climate risk management efforts; and engage with industry stakeholders to stay abreast of emerging trends

The ultimate success of any set of changes depends on the abilities of those charged with enacting the new processes / programmes. Building the capabilities of the bankers can help to sustain success.

Step 3: Implement changes (4/4)

Implementation of these updated systems will equip individual bankers to make more informed decisions at the transaction level. Adopting the lens of the hazard-exposure-vulnerability—the bank exposure framework outlined in Chapter 2—will help the bank gain insights into specific areas where improvements can be made. Further, banks can take several measures for each of these framework components to further integrate climate-informed decision making into how they approach the risk associated with each transaction.

Figure 16: Examples of measures for climate informed decision making at individual banker level

Framework level	Action items	Level of influence	Example of measures
Hazard and asset exposure	**Reduce the severity of hazards or limit the expected exposure to those hazards**		**Suggest alternatives** – While the banker has limited ability to reduce the severity and frequency of climate-related hazards and/or the exposure of an asset to these hazards, he/she can help the asset owner before they build the asset (or expand an existing asset) by encouraging them to build in (or move to) a location less susceptible to climate hazards
Vulnerability	**Increase the resilience of the asset to the downside impact of climate events**		**Finance resilience investment:** Fund / extend loans to support investment to build resilience (e.g., fund the acquisition of new pumps to limit the impact of floods) **Implement reporting standards:** Require certain reporting standards or as a prerequisite for funding (e.g., require climate resilience plan as part of commercial due diligence) **Provide risk assessment tools and services:** Provide tools / internal consulting services as a value added service to help clients better understand physical climate risks **Serve as a connector and convener:** Act as a connector / convener for clients wanting to learn more about the issue or to find solutions
Fis' total exposure	**Limit the bank's exposure to those climate risks** (without changing capital allocation requirement, which is determined at the firm level)		**Enable pricing decisions:** Adjust pricing of the loan/s in accordance with the degree of risk faced; lower interest rates or higher loan amounts can be considered for assets that have integrated adaptation and resilience measures **Engage in risk-sharing mechanisms:** • Form a syndicate with other financial institutions to reduce individual exposure on large projects and share risk • Procure climate risk insurance by investing in climate risk insurance policies to mitigate potential losses associated with an asset that is highly vulnerable to climate events **Diversify investments:** Spread out investments across different sectors and geographic regions to reduce concentration risk in climate-vulnerable areas

Low — High influence

Many of these changes will be gradual, but banks must adopt a practical approach that works best for them. Most financial institutions have yet to incorporate climate risk management extensively into their portfolios. Mechanisms such as adjusting the pricing to the perceived level of risk can help compensate for the perceived risk, though the bank-wide incorporation of these measures will likely be gradual. Banks will likely need to take a pragmatic approach to initiating these practices and adapting them to their own portfolio.

Training and ongoing support

Develop targeted training modules for teams (Business, Credit, Risk, etc.) and skills (Physical Climate Risk Assessment) in collaboration with Banking Associations

Establish the National Climate Risk Alliance as a platform for FIs

Guidelines for integrating climate-related financial risks into the Internal Capital and Liquidity Adequacy Assessment Processes

Feedback loops

Mechanisms for collecting feedback from employees and stakeholders enable banks to identify barriers, address concerns, and make necessary adjustments in real time, promoting agility, continuous improvement, and long-term success.

Call out: Opportunities in green financing

While physical climate risks can have significant financial implications, the growth of green finance offers tremendous business opportunities for banks. Climate change implies inherent risk escalation, but the substantial growth of climate-related initiatives in recent years has presented banks with many new opportunities. Global climate financing (a sub-set of green financing) reached USD 1.3 trillion annually in 2022—a substantial increase from USD 653 billion in 2020.[2] Undertaking climate risk assessments of the credit life cycle can help banks uncover new avenues to explore.

Figure 17: Opportunities arising from climate risk assessments (non-exhaustive)

1 Support existing clients in building climate resilience	2 Finance businesses that take advantage of new climate conditions	3 Finance the transition to a low-carbon economy	4 Leverage enhanced climate capabilities to improve other processes and systems
Implement measures to enhance the resilience of assets vulnerable to climate events	Support initiatives that are well positioned to thrive in a changing climate landscape.	Allocate capital to renewable energy projects to ensure long-term growth amidst a global clean energy transition	Invest in new climate technologies that can also improve the bank's broader capabilities
Examples: **Infrastructure:** Lend to municipal corporations to build flood barriers for key assets **Commercial real estate:** Provide loans for the installation of green roofs and rainwater harvesting systems to improve water management and reduce the urban heat island effect **Agriculture:** Provide additional credit to promote the development of drought-resistant crops and irrigation systems for agricultural clients in regions prone to water scarcity	**Examples:** **Agriculture:** Support the expansion of vineyards into regions experiencing milder climates and longer growing seasons **Aquaculture:** Provide financing for aquaculture projects in areas with warmer water, enabling the cultivation of species that were previously limited by temperature constraints **Agriculture:** Support the construction of greenhouses and indoor vertical farming facilities to produce crops year-round in regions with extreme weather conditions or limited arable land	**Examples:** **Renewable energy:** Invest in utility-scale solar photovoltaic (PV) projects to increase renewable energy generation capacity and reduce reliance on fossil fuels **Transportation:** Provide financing for the installation of electric vehicle (EV) charging infrastructure, including fast-charging stations along highways and in urban areas **Real estate:** Fund energy efficiency retrofit projects for residential and commercial buildings, such as upgrading insulation and installing energy-efficient lighting and appliances	**Examples:** **Satellite-based monitoring systems:** Implement satellite-based monitoring systems to assess deforestation risks in agricultural supply chains, in order to identify potential disruptions and develop more resilient sourcing strategies **AI algorithms:** Use AI algorithms to analyze climate data and optimize energy consumption in manufacturing processes (and enhance the bank's expertise in data analytics and process optimization) **Blockchain technology:** Leverage blockchain technology to enhance transparency and traceability in carbon credit markets, enhancing the bank's expertise in fintech and digital innovation, and allowing it to apply this technology to other areas such as enhancing security in payment processing

Call out: Opportunities in green financing

Given the diversity of new avenues, banks in LMICs have the opportunity to pursue a range of new products in green finance. The landscape of sustainable finance instruments has evolved significantly in the last few decades. FIs worldwide are spearheading the development and utilization of diverse mechanisms to bolster their climate investments. These instruments include a spectrum of debt and equity-based financial products tailored to address the urgent need for sustainable development and climate resilience. The table below encapsulates the key opportunities within these major instruments for banks in LMICs to tap into, and the potential risks to keep in mind while considering investments.

Table 3: Details of available instruments within green financing

	Instrument	Description	Opportunity	Potential risk
A	**Green bonds and loans**	Green bonds are debt instruments designed to raise capital for projects with environmental benefits, such as renewable energy, energy efficiency, or sustainable infrastructure	By issuing these bonds, banks can diversify their investor base and benefit from favorable bond pricing due to strong investor demand for green bonds today	Greenwashing may hurt the bank's reputation; green projects may have non-traditional collateral and pose challenges in loan recovery; evolving government policies might affect their viability
B	**Sustainability linked loans**	These loans are credit facilities in which the terms, including interest rates, are tied to the borrower's achievement of predetermined sustainability targets	Banks can directly influence impact by incentivizing borrowers to implement and maintain sustainable initiatives while safeguarding their financial interests in case targets are not met	Inaccurate sustainability metrics can lead to a loss of credibility, damaging the bank's reputation as a responsible and sustainable lender; further, if targets are not met, this might impact loan repayment
C	**Voluntary credit markets**	Carbon credits arise when firms participate in a voluntary credit market and then reduce or sequester greenhouse gas emissions	Trading in carbon markets (or related offset / credit markets) provides a new avenue for growth and trading revenues	Green markets remain immature and risks are not well understood, potentially exposing banks to uncertain risk
D	**Climate investment funds including green private equity funds**	Climate funds are focused on financing climate-related projects, including renewable energy, climate adaptation, and sustainable development initiatives	The bank can provide advisory services, sell new products and provide trading/hedging services to the fund; wealth management services in banks can offer asset management services	Banks investing in climate funds may face compliance risks stemming from regulatory changes in climate policies, ESG standards, or financial regulations

Note: The list of debt and equity instruments above is not exhaustive. Its purpose is to offer insight into some of the well-established instruments currently utilized in climate finance and highlight corresponding opportunities for banks.

Call out: Opportunities in green financing

Government support will be crucial to bolster the still nascent green finance market in LMICs. LMIC markets are in early stages compared to there global counterparts. For example India's green bond issuance amounted to US$ 7.15 billion in November 2018, significantly less than the USA (US$ 34 billion) and China (US$ 31 billion).[2] While green finance presents significant environmental and societal benefits, these initiatives must also make commercial sense and be financially viable for financial institutions to actively participate. Institutions will need to carefully evaluate the risk-return profile of green finance opportunities to ensure that they align with their fiduciary responsibilities and growth objectives. Despite projections that India would issue US$ 3 billion of green bonds in the financial year 2023–2024, this still amounts to only 1.6% of its overall annual borrowing.[3] Governments in LMICs can help catalyze the growth of green finance markets by releasing climate-related financial guidelines and launching government-based incentives, such as expanding the ambit of priority sector lending to climate adaptation efforts, among other actions.

Step 4: Track progress

Implementing a system for establishing and tracking targets is essential for effective climate risk management. By setting measurable goals for incorporating climate risk management, the bank can monitor progress and ensure accountability. This approach allows for clear visibility into actions taken and their outcomes, facilitating informed decision making. Draft regulatory guidelines requires financial institutions to disclose:

- The metrics they are using to assess climate-related financial risks and opportunities in line with their strategy and risk management process
- Scope 1, Scope 2, and Scope 3 greenhouse gas (GHG) emissions and the related risks
- The targets leveraged to manage climate-related risks, opportunities, and performance against targets

Beyond the above-mentioned disclosure requirements, having a formal tracking process can help financial institutions enhance their overall risk management practices and improve decision-making processes.

The following three-step approach can allow financial institutions to monitor their efforts, assess performance, and gain insights that can help them adapt their strategy to incorporate effective climate risk management into their processes.

Figure 18: Three-step approach to monitor and track progress

Develop a tracking framework

Establish objectives and targets: Define the objectives of the tracking framework based on the institution's climate risk management goals and overall strategic priorities.

Identify metrics: Determine the specific climate risk metrics to be tracked. Metrics should reflect whether overarching objectives have been achieved and track the progress made toward those goals.

Implement a formal tracking system

Select tools and technologies: Choose appropriate tools and technologies to facilitate data collection, storage, and analysis, ensuring compatibility with the institution's existing systems and processes.

Provide training: Educate relevant stakeholders on how to use the tracking system effectively, ensuring widespread understanding and adoption across the organization.

Conduct periodic analyses and generate insights

Develop a transparent reporting mechanism: Regularly analyze relevant data to assess progress toward established objectives and targets, identifying areas of strength and opportunities for improvement.

Identify and report trends and insights: Identify trends and patterns within the data to gain insights into the institution's climate risk exposure, enabling informed decision-making and strategic planning. Develop a formalized system to ensure that metrics are reported to senior management, including the board.

Readily achievable actions

Integrate a set of simple metrics into existing reporting structures

Conduct a preliminary assessment to identify data gaps. By assessing these gaps, institutions can prioritize data collection efforts and develop strategies to enhance data comprehensiveness

Way forward

Key Messages

1. Embedding physical climate risk assessments is a long journey requiring collaborative efforts to address several constraints. Three constraints require urgent attention:
   - Lack of reliable data for projecting climate hazards
   - Limited standardization and guidance on how physical climate risks can be translated into financial risks or loss metrics
   - Absence of macro-level action or guidance tying climate risk assessments to capital allocation decisions

   Addressing these gaps will require collaborative action between multiple stakeholders such as policymakers, regulators, FIs, and data providers.

Next steps to standardize conducting climate risk assessments in the ecosystem (1/4)

Physical climate risk assessment must be established as a standard practice across FIs. However, there are several ecosystem-wide constraints that need to be addressed to facilitate the adoption of these practices. Three key gaps that require urgent action stand out:

1. Lack of reliable data for projecting climate hazards. While the previous chapters highlight how FIs can obtain hazard data for different scenarios and spotlight data sources such as GIRI, lack of data remains the most prominent challenge constraining FIs from accurately assessing physical climate risks
2. Limited standardization and guidance on how physical climate risks can be translated into financial risks or loss metrics
3. Absence of macro-level action or guidance tying climate risk assessments to capital allocation decisions in the sector.

Collective action is needed to address these challenges and build positive momentum in the sector. A range of actors—including the policymakers, regulator, climate service providers, and FIs—will need to work collectively to strengthen the ecosystem and lay the foundation for instituting climate risk assessment as a standard practice. Figure 19 lays out the urgent actions needed in the ecosystem. The pages that follow describe in greater detail the specific steps that would need to be taken for each of these actions to succeed.

Figure 19: Three focus areas for institutionalizing climate risk assessments across the ecosystem

Focus areas	Gaps	Action needed
Solve data gaps	There is no common database for climate-related hazards, nor are data collection metrics standardized	**As a public good, build a platform for climate-related hazard data** and prescribe norms for collecting asset-level climate data
Understand climate-induced financial risk	Once a climate risk assessment has been conducted, more guidance is needed on how to convert physical climate risk into financial risk	**Standardize methods for deriving financial risk** from physical climate risks
Address macro implications	Guidance is lacking on how to apply climate risk to capital allocation decisions[a]	**Standardize guidelines for applying climate considerations** to credit and capital decisions

Notes: (a) European Central Bank laid out a few best practices/guidelines on this in their document "Good practices for climate-related and environmental risk management"

Next steps to standardize conducting climate risk assessments in the ecosystem (2/4)

Solve data gaps

Policymakers and the financial sector regulator should initiate steps to set up a common data repository for climate data and standardize processes related to data collection. Building their own hazard databases from scratch can be prohibitively expensive for most FIs and lead to redundancy of efforts across sectors. A public climate data platform for LMICs—especially one endorsed or supported by the government—that serves as a repository of historical climate hazard data and forward-looking projections can help:

- Bridge the key gap around lack of climate hazard data at a sufficient spatial resolution to effectively assess an asset's physical climate risks
- Make it cost effective for financial institutions to access climate hazard data for their risk assessment exercises and inform decision making
- Establish a verified source of data in which financial institutions and other stakeholders can feel greater confidence
- Inspire further research and increase climate assessment–related services by actors such as CDRI and other private providers to further bolster the ecosystem

Moreover, standardizing the types of data to be collected for determining climate-induced risk—as has been done for credit data—would enable FIs to assess climate-related risks more consistently across the ecosystem, thereby enhancing the sector's resilience to climate risks.

Table 4 below lays out the roles different actors can play in acting on this recommendation.

Table 4: Case study from India on the role of different actors in solving data gaps

What the ecosystem needs	What can ecosystem-level actors do?	What can FIs do?
As a public good, build a platform for climate-related hazard data (see box 7 as an example)	**Policymakers:** Relevant union ministries, including the Ministry of Earth Sciences, Ministry of Environment, Forests, and Climate Change, and the Ministry of Finance, can consider commissioning the creation of a standardized hazard data repository and ensure that it is continuously updated. **RBIH:** The Reserve Bank of India Innovation Hub is uniquely positioned to take the lead in developing a standardized platform that can serve as the trusted source of climate risk information for the financial sector.	**Industry associations:** A consortium of FIs (e.g., IBA for banks) could spearhead the advocacy for the creation of this database. As an interim measure, it could also help set up data standardization guidelines or an interim hazard data repository that all banks can access to promote uniformity in risk assessment.
Prescribe standard asset-level climate-related data collection norms	**Financial regulator:** The regulator can explore and ultimately mandate the standardization of climate data collection processes, as well as endorse the climate data repository (when established) to ensure traction among FIs. **Sectoral regulators:** Boards such as the Central Electricity Regulatory Commission (CERC) could potentially collaborate and mandate the collection of climate-related data at the asset level.	**Individual institutions:** Individual FIs can collaborate with industry associations and technology providers to develop standardized data collection frameworks and contribute to the establishment of a common repository for climate-related data, as has been accomplished with credit bureaus and fixed and movable asset registries in India.

Next steps to standardize conducting climate risk assessments in the ecosystem (3/4)

Box 7: Example of a public good dataset for climate

Cal-Adapt serves as an example of a "public common dataset" for climate-related information. Developed by the Geospatial Innovation Facility at the University of California, Berkeley, with funding and advisory oversight from the California Energy Commission and the California Strategic Growth Council, Cal-Adapt is a central data repository for the state of California in the United States. Its purpose is to provide the public, researchers, government agencies, and industry stakeholders with essential data and tools for climate adaptation planning, building resilience, and fostering community engagement. This platform underscores the value of establishing such common data repositories to consolidate and democratize access to critical climate information. India could greatly benefit from developing a similar centralized platform to serve the needs of its diverse stakeholders involved in climate action and resilience-building efforts. However, it is important to note that institutions should not blindly copy the Cal-Adapt model, as India will have its own specific needs and contexts. Instead, the Cal-Adapt example can serve as an inspirational reference point, encouraging Indian institutions to tailor any such initiative to the unique requirements and challenges of the Indian landscape.

Learn more on this link : https://cal-adapt.org/

Understand Climate-Induced Financial Risk

The financial sector should collaborate to establish guidelines on translating physical climate risks into financial risks. Physical climate risks can translate into financial risk through multiple channels. These include (non-exhaustive):

1. **Credit risk:** Higher likelihood of borrowers defaulting, especially in climate-vulnerable industries like infrastructure projects. This can lead to credit rating downgrades, resulting in higher risk for lenders.
2. **Market risk:** Decreased property and asset values in areas prone to flooding, storms, heat waves, and coastal erosion. This can lower the market value of equity and bond investments held by financial institutions.
3. **Operational risk:** Increased costs to maintain and operate infrastructure like data centres, as well as disruptions to the continuity of banking operations

Regulatory guidelines could emphasize the importance of disclosing climate risks and risk management practices related to them. However, ambiguity regarding the methodology for converting physical climate risk into financial risk can result in financial institutions developing their own methodologies. Thus, more prescriptive guidance within the financial system to facilitate this process can make disclosures more comparable and help ensure standardization in how banks treat similar risks.

Table 5 lays out the roles different actors can play in acting on this recommendation.

Table 5: Role of different actors in understanding climate-induced financial risks

What the ecosystem needs	What ecosystem-level actions can help?	What can Individual FIs do?
Guidance for the financial system on converting physical climate risk (assuming data are available) to financial risk.	**Regulator:** The regulator could consider establishing a committee that will publish more prescriptive guidance on converting physical climate risk to financial risk, ensuring clarity and consistency in reporting standards.	**FIs:** Individual institutions can consult with the regulator to inform standards and share knowledge in appropriate forums to move the industry toward convergence on frameworks and best practices.

Next steps to standardize conducting climate risk assessments in the ecosystem (4/4)

Address macro implications

Conduct a comprehensive assessment of macro and micro prudential implications of physical climate risks and introduce standardize guidelines on how to factor them in decision making.

At the micro level, individual FIs can undertake comprehensive assessments of physical climate risks that inform their decisions on how to manage their exposure and safeguard financial stability. However, lack of consistency in making capital allocation decisions can lead to fragmentation and make it challenging to aggregate and analyze financial impact data at the macro level. This can pose significant obstacles for regulators, policymakers, and other stakeholders in assessing systemic risks and formulating coordinated responses.

Therefore, at the macro level, concerted efforts are needed to establish standardized guidelines and frameworks for assessing and managing climate-related risks across the financial sector. It is imperative for regulatory bodies like the Central Bank or the Financial Stability and Development Council (FSDC) to oversee the establishment of these guidelines and to ensure that banks have access to them for making informed credit and capital decisions. Regardless of whether banks conduct climate risk assessments internally or seek help from rating agencies, regulatory oversight and guidance are paramount in managing the financial ramifications of physical climate risks within the financial sector.

Table 6: Roles of different actors in addressing macro implications of physical climate risks

What the ecosystem needs	What ecosystem-level actions can help?	What can Individual FI's do?
Standardized guidelines on applying climate considerations to credit and capital decisions	**Regulator:** Regulator can take the lead in conducting a comprehensive assessment of the macro implications of physical climate risks on the financial systems and establish standardized guidelines. Comprehensive risk assessment solutions, including scenario analysis (i.e. Integrated Assessment Models [IAM], NGFS, International Energy Agency [IEA] etc.), stress testing and sensitivity analysis will play a significant role in quantifying climate-related financial risks or informing strategic planning. Standard scenarios to be defined and ensure availability to all the stakeholders. Defined standard time frame for 'short term', 'medium term' and 'long term' horizon across FIs.	**FIs:** Individually or collectively, FIs can advocate for the establishment of these guidelines and provide inputs on their development.

CDRI's role

Where can CDRI help in solving data gaps

- Evolve GIRI into a central repository for comprehensive, standardized data on climate-related hazards, providing FIs with a robust and trusted platform to access critical information for accurate risk assessments
- Collaborate with the regulators and FIs to enhance GIRI's capabilities in line with the financial sector's needs, helping the platform become the go-to resource for natural hazards and disaster risk assessment data

Where can CDRI help in understanding climate induced financial risk

- The ecosystem could leverage CDRI's understanding of how average annual loss and probable maximum loss are computed for different infrastructure sectors on the GIRI platform. This insight could help inform the development of sector-wide guidelines for translating physical climate risk into financial risk. Further, CDRI can facilitate knowledge sharing and capacity building initiatives to ensure that FIs and stakeholders can effectively implement these guidelines.

How can CDRI help in addressing macro implications

- CDRI can play a pivotal role in helping the ecosystem understand the macro-level implications of physical climate risks for the financial systems in the LMICs. GIRI provides valuable insights into the expected loss at the national level, offering a foundational understanding of macro-level risks. This tool serves as a starting point for assessing the broader implications of physical climate risks on the financial ecosystem, allowing stakeholders to identify key areas of concern and develop targeted strategies for mitigation and adaptation. Furthermore, CDRI can collaborate with regulatory bodies and other stakeholders to translate these insights into actionable guidelines and recommendations, ensuring a coordinated approach to managing macro-level risks.

Annex

Contents

Annex 1: Checklist for FIs for steps given in the playbook

This checklist has been developed based on the steps outlined in this playbook to support financial institutions (FIs) in their journey towards integrating climate risk assessments into their decision-making processes.

S. No.	Step	Checkbox
1	Define the needs and objectives	☐
2	Set out the right-sized scope and approach	☐
3	Choose climate scenarios and estimate the impact	☐
3.1	Step 1 – Aligning on climate scenarios	☐
3.2	Step 2 – Hazard and Exposure	☐
3.3	Step 3 - Vulnerability	☐
3.4	Step 4 – Projecting the level of climate risk	☐
3.5	Step 5 – Understanding risk in relation to FI's total exposure	☐
4	Present and interpret the results	☐

Annex 2: Glossary (1/3)

Term	Definition	Source
Average annual loss (AAL)	AAL is a measure of annualized future losses over the long term, derived from probabilistic risk models. The AAL estimates losses that are likely to occur every year due to a specific hazard. For example, if a bank's loan portfolio is exposed to flood risks, calculating the AAL helps quantify the expected financial impact of flooding on an annual basis. Understanding AAL assists FIs in estimating potential losses and allocating resources for risk management and mitigation strategies.	United Nations Office for Disaster Risk Reduction (UNDRR)
Climate adaptation	Adaptation refers to the process of adjustment to actual or expected climate and its effects. In the context of FIs, climate adaptation efforts focus on assessing how changing climate conditions may affect loan portfolios and investments, identifying vulnerable sectors or regions, and developing financial products and services that support resilience-building initiatives.	Intergovernmental Panel on Climate Change (IPCC)
Climate hazard	Climate hazard refers to climate-related physical events or trends or their physical impacts that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.	Intergovernmental Panel on Climate Change (IPCC)
Climate mitigation	Climate mitigation refers to human intervention to reduce the sources or enhance the sinks of greenhouse gases. FIs play a crucial role in climate mitigation by financing projects and investments that promote renewable energy, energy efficiency, and sustainable land use practices.	Intergovernmental Panel on Climate Change (IPCC)
Climate resilience	Climate resilience refers to the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure. In the financial sector, building climate resilience involves assessing the vulnerability of assets and investments to physical climate risks, developing risk management strategies, and integrating resilience building measures into lending practices and investment decisions.	Intergovernmental Panel on Climate Change (IPCC)
Climate scenario	A climate scenario is a plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for the explicit use of investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate scenarios can help FIs understand future climate risks.	Intergovernmental Panel on Climate Change (IPCC)
Coastal flood	Coastal flooding is most frequently the result of storm surges and high winds coinciding with high tides. The surge itself is the result of the rising of sea levels due to low atmospheric pressure. In particular configurations, such as major estuaries or confined sea areas, the piling up of water is amplified by a combination of the shallowing of the seabed and retarding of return flow.	United Nations Office for Disaster Risk Reduction (UNDRR)
Credit exposure	Credit exposure refers to the amount of exposure to the risk of suffering a loss in a particular transaction or with respect to any kind of investment. It represents the amount an investor stands to lose in an investment or loan should it fail. In the context of physical climate risks, credit exposure may increase due to the impact of climate-related events on borrowers' ability to repay loans or fulfill contractual obligations.	Task Force on Nature related Financial Disclosure (TNFD)
Critical infrastructure	Critical infrastructure refers to physical structures, facilities, networks, and other assets that provide services that are indispensable to the social and economic functioning of society, and that are necessary for managing disaster risk.	Coalition for Disaster Resilient Infrastructure (CDRI)

Annex 2: Glossary (2/3)

Term	Definition	Source
Cyclone	A cyclone is a region of the atmosphere in which the pressures are lower than those of the surrounding region at the same level. Depending on the size of a cyclone, the impact can extend over a very wide area, with strong winds and heavy rain. However, the greatest damage to life and property is not from the wind, but from secondary events such as storm surges, flooding, landslides and tornadoes.	United Nations Office for Disaster Risk Reduction (UNDRR)
Drought	Drought is a prolonged dry period in the natural climate cycle that can occur anywhere in the world. It is a slow onset phenomenon caused by a lack of rainfall.	World Meteorological Organization (WMO)
Exposure	The presence of people; livelihoods; species or ecosystems; environmental functions; services and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected by climate hazards.	Intergovernmental Panel on Climate Change (IPCC)
Extreme weather events	An extreme weather event is an event that is rare at a particular place and time of year. These are becoming more frequent and intense due to climate change, posing challenges for FIs by increasing the risk of physical damage to assets, disruptions to business operations, and losses in revenue and profitability.	Intergovernmental Panel on Climate Change (IPCC)
Fluvial (riverine) flood	A fluvial flood is a rise, usually brief, in the water level of a stream or water body to a peak from which the water level recedes at a slower rate.	United Nations Office for Disaster Risk Reduction (UNDRR)
Green bond	Green bonds are financial instruments that finance green projects and provide investors with regular or fixed income payments. Examples include projects related to renewable energy, energy efficiency, sustainable agriculture, and climate adaptation.	World Bank
Green loan	A green loan is a form of financing that enables borrowers to use the proceeds to exclusively fund projects that make a substantial contribution to an environmental objective. A green loan is similar to a green bond in that it raises capital for green-eligible projects. However, a green loan is based on a loan that is typically smaller than a bond and done in a private operation.	World Bank
Landslide	Landslide is the downslope movement of soil, rock and organic materials under the effects of gravity, which occurs when the gravitational driving forces exceed the frictional resistance of the material resisting on the slope.	United Nations Office for Disaster Risk Reduction (UNDRR)
Loss given default	The fraction of a loan or security's nominal value that would not be recovered following default	International Monetary Fund (IMF)
Physical climate risk	Physical climate risks are related to the physical impacts of climate change that can have direct financial implications for organizations, such as damage to assets. They can pose significant challenges to Fis by threatening the value and performance of their assets.	Task Force on Climate related Financial Disclosures (TCFD)

Annex 2: Glossary (3/3)

Term	Definition	Source
Precipitation	Precipitation is the water released from clouds in the form of rain, freezing rain, sleet, snow, or hail	World Bank
Probability of default	The likelihood that a loan or security will not be repaid and will fall into default	International Monetary Fund (IMF)
Resilient infrastructure	Resilient infrastructure refers to infrastructure systems and networks, the components, and assets thereof, and the services they provide, that are able to resist and absorb disaster impacts, maintain adequate levels of service continuity during crises, and swiftly recover in such a manner that future risks are reduced or prevented.	Coalition for Disaster Resilient Infrastructure (CDRI)
Transition risk	Transition risk refers to risks faced while transitioning to a lowercarbon economy. The transition entails extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change. Depending on the nature, speed, and focus of these changes, transition risks may pose varying levels of risks to financial organizations.	Task Force on Climate related Financial Disclosures (TFCD)
Value-at-risk (VaR)	VaR is a method for calculating and controlling exposure to market risk. VaR is a single number (currency amount) that estimates the maximum expected loss of a portfolio over a given time horizon (the holding period) and at a given confidence level. A VaR modeling approach to climate risk assessment can provide financial institutions a nuanced understanding of risks on their portfolios.	Reserve Bank of India (RBI)
Voluntary carbon markets	Voluntary carbon markets refer to the issuance, buying, and selling of carbon credits, on a voluntary basis. One tradable carbon credit equals one tonne of carbon dioxide (or the equivalent amount of a different greenhouse gas) reduced, sequestered or avoided. FIs can engage in voluntary carbon markets by facilitating transactions, providing financial services, and investing in carbon offset projects.	United Nations Development Program (UNDP)
Vulnerability	Vulnerability refers to propensity or predisposition to be adversely affected. It encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Vulnerability assessment helps FIs identify high-risk areas, prioritize adaptation measures, and support vulnerable communities in building resilience.	Intergovernmental Panel on Climate Change (IPCC)
Watershed	A watershed is a land area, also referred to as drainage basin or catchment, that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as reservoirs, bays, and the ocean.	World Bank

Annex 3: Sources of Glossary (1/2)

Table 7 : Details on sources used in glossary

Average Annual Loss	United Nations Office for Disaster Risk Reduction	https://www.preventionweb.net/english/hyogo/gar/2013/en/garpdf/Annex_1.pdf
Climate Adaptation	Intergovernmental Panel on Climate Change	https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf
Climate Hazard	Intergovernmental Panel on Climate Change	https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf
Climate Mitigation	Intergovernmental Panel on Climate Change	https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf
Climate Resilience	Intergovernmental Panel on Climate Change	https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf
Climate Scenario	Intergovernmental Panel on Climate Change	https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf
Coastal flood	United Nations Office for Disaster Risk Reduction	https://www.undrr.org/hips-cluster/flood
Credit Exposure	Task Force on Nature related Financial Disclosures	https://tnfd.global/wpcontent/uploads/2023/09/Glossary_of_key_terms_v1.pdf?v=1695138274
Critical Infrastructure	Coalition for Disaster Resilient Infrastructure (CDRI)	https://giri.unepgrid.ch/glossary?page=2
Cyclone	United Nations Office for Disaster Risk Reduction	https://www.undrr.org/understanding-disasterrisk/terminology/hips/mh0030
Drought	World Meteorological Organisation	https://wmo.int/about-us/world-meteorological-day/wmd-2020/drought
Exposure	Intergovernmental Panel on Climate Change	https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf
Extreme Weather Events	Intergovernmental Panel on Climate Change	https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf
Fluvial (riverine) Flood	United Nations Office for Disaster Risk Reduction	https://www.undrr.org/hips-cluster/flood
Green Bond	World Bank	https://www.worldbank.org/en/news/feature/2021/12/08/what-youneed-to-know-about-ifc-s-green-bonds
Green Loan	World Bank	https://www.worldbank.org/en/news/feature/2021/10/04/what-youneed-to-know-about-green-loans

Annex 3: Sources of Glossary (2/2)

Landslide	United Nations Office for Disaster Risk Reduction	https://www.undrr.org/understanding-disasterrisk/terminology/hips/gh0007#:~:text=Landslide%20is%20the%20downslope%20movement,submarine%20(Varnes%2C%201978).
Loss Given Default	International Monetary Fund	https://www.imf.org/-/media/Websites/IMF/imported-flagship-issues/external/pubs/ft/GFSR/2008/02/pdf/_glossarypdf.ashx
Physical Climate Risk	Task Force on Climate related Financial Disclosures	https://www.tcfdhub.org/Downloads/pdfs/E06%20-%20Climate%20related%20risks%20and%20opportunities.pdf
Precipitation	World Bank	https://climateknowledgeportal.worldbank.org/media/document/CCKP_glossary.pdf
Probability of Default	International Monetary Fund	https://www.imf.org/-/media/Websites/IMF/imported-flagship-issues/external/pubs/ft/GFSR/2008/02/pdf/_glossarypdf.ashx
Resilient Infrastructure	Coalition for Disaster Resilient Infrastructure (CDRI)	https://giri.unepgrid.ch/glossary?page=2
Transition Risk	Task Force on Climate related Financial Disclosures	https://www.tcfdhub.org/Downloads/pdfs/E06%20-%20Climate%20related%20risks%20and%20opportunities.pdf
VaR	Reserve Bank of India	https://www.rbi.org.in/commonperson/English/Scripts/Notification.aspx?Id=1461#20
Voluntary Carbon Markets	United Nations Development Program	https://climatepromise.undp.org/news-and-stories/what-arecarbon-markets-and-why-are-they-important
Vulnerability	Intergovernmental Panel on Climate Change	https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf
Watershed	World Bank	https://climateknowledgeportal.worldbank.org/media/document/CCKP_glossary.pdf

Annex 4: Acronyms and abbreviations

AAL	Average annual loss
CAPEX	Capital expenditure
CDRI	Coalition for Disaster Resilient Infrastructure
CEEW	Council on Energy, Environment, and Water
CPI	Climate Policy Initiative
DST-IIT	Department of Science and Technology, Indian Institute of Technology
EV	Electric Vehicle
FI	Financial Institution
GHG	Greenhouse gas
GIRI	Global Infrastructure Resilience Index
GRI	Global Resilience Index
HEV	Hazard-exposure-vulnerability
IFRS	International Financial Reporting Standards
IPCC	Intergovernmental Panel on Climate Change
ISSB	International Sustainability Standards Board
LGD	Loss given default
MTPA	Millions of tonnes per annum
NEX GDDP	NASA Earth Exchange Global Daily Downscaled Climate Projections
NGFS	Network for Greening the Financial System
NPA	Non-performing asset
NRI	Non-resident Indian
OPEX	Operational expenditure
PD	Probability of default
PPP	Public-private partnership
PV	Photovoltaic
RBI	Reserve Bank of India
RCP	Representative Concentration Pathway
SaaS	Software as a service
SSP	Shared Socioeconomic Pathways
TCFD	Task Force on Climate-related Financial Disclosures
TERI	The Energy and Resources Institute
VaR	Value-at-risk
WRI	World Resources Institute

Annex 5: List of Figures

Annex 6: List of Tables

Annex 7: List of Boxes

Annex 8: References

Introduction

1. Global Climate Risk Index, Germanwatch, 2021, available here: https://www.germanwatch.org/en/cri#:~:text=Global%20Climate%20Risk%20Index%202021&text=The%20countries%20 and%20territories%20affected,Myanmar%20and%20Haiti%20rank%20highest.
2. Climate risk is financial risk – For banks it's a board-level issue, KPMG, 2021, available here: https://kpmg.com/xx/en/home/insights/2021/04/banks-climate-change-reporting.html
3. Climate disclosures withing the annual Financial Reports of Banks (phase 1), Benchmarking on how banks reported on climate change in the 2020 reporting season, KPMG, 2021, available here: https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2021/05/climate-blog-1.pdf
4. Adaptation Finance: 11 Key Questions, Answered, World Resource Institute, 2022, available here: https://www.wri.org/insights/adaptation-finance-explained

Chapter 1 (1/2)

1. CDRI (2023). Global Infrastructure Resilience: Capturing the Resilience Dividend - A Biennial Report from the Coalition for Disaster Resilient Infrastructure. New Delhi. https://doi.org/10.59375/biennialreport.ed1
2. The global GDP growth in 2021-22 was 5.8% on the ~US$ 100 trillion global GDP.
3. This number includes buildings. The value for six infrastructure sectors which includes power, roads and railways, ports and airports, water and wastewater, telecommunications and oil and gas.
4. The World Bank categorization for defining LMICs has been used across this document. Data and information retrieved from: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.
5. Total number of LMICs globally as per The World Bank categorization.
6. GIRI data is available at: https://giri.unepgrid.ch/facts-figures/multi-hazards. All data has been taken from the platform unless otherwise mentioned.
7. There are a total of 94 countries in the three regions as per The World Bank categorization. The analysis includes 82 countries.
8. 11 countries including ten from East Asia and Pacific and one country from Sub-Saharan Africa are not included in the data analysis.
9. https://documents1.worldbank.org/curated/en/760481644944260441/pdf/Assessing-Financial-Risks-from-Physical-Climate-Shocks-A-Framework-for-Scenario-Generation.pdf
10. UNEP (n.d., p.1). Climate Risk and TCFD programme. UNEP Finance initiative. Available at: https://www.unepfi.org/climate-change/tcfd/
11. NGFS (n.d.). Scenarios Portal. Available at: https://www.ngfs.net/ngfs-scenarios-portal/
12. Carbone 4 (n.d.). CIARA. Available at: https://www.carbone4.com/en/expertises/innovation/ciara
13. equitix (2023). Equitix Climate Report. Available at: https://equitix.com/wp-content/uploads/2024/07/Equitix-Climate-Report-YE-2023.pdf
14. European Bank for Reconstruction and Development, Global Centre of Excellence on Climate Adaptation (2018). Advancing TCFD guidance on physical climate risks and opportunities. Available at: https://www.physicalclimaterisk.com/media/EBRD-GCECA_draft_final_report_full.pdf
15. European Investment Bank (2022). Joint methodology for tracking climate change adaptation finance. Available at: https://thedocs.worldbank.org/en/doc/20cd787e947dbf44598741469538a4ab-0020012022/original/20220242-mdbs-joint-methodology-climate-change-adaptation-finance-en.pdf

Annex 8: References

Chapter 1 (2/2)

16. https://www.unepfi.org/wordpress/wp-content/uploads/2024/10/ARIC-PCR-Playbook-2.pdf
17. Climate Financial Risk Forum (2024). Mobilising adaptation finance to build resilience. Available at: https://www.fca.org.uk/publication/corporate/cfrf-mobilising-adaptation-finance-build-resilience-2024.pdf
18. United Nations Office for Disaster Risk Reduction (UNDRR), Standard Chartered Bank and KPMG International (2024). Guide for Adaptation and Resilience Finance, p.1. Available at: https://www.undrr.org/publication/guide-adaptation-and-resilience-finance
19. United Nations Office for Disaster Risk Reduction (UNDRR), Standard Chartered Bank and KPMG International (2024). Guide for Adaptation and Resilience Finance, p.6. Available at: https://www.undrr.org/media/95342/download?startDownload=20241025
20. Climate Bonds Initiative (n.d.). Resilience Taxonomy. Available at: https://www.climatebonds.net/files/page/files/resilience_brochure_v5.pdf
21. EDHEC (2022). The 2022 edition of TICCS® now includes sustainability mappings and hydrogen assets, p.1. Available at: https://scientificinfra.com/announcement/the-2022-edition-of-ticcs-now-includes-sustainability-mappings-and-hydrogen-assets/
22. Howden (n.d.) Helping leaders optimise the big decisions ahead. Available at: https://www.howdengroup.com/uk-en/climate-risk-and-resilience/resilience-laboratory
23. Ranger, N. and Bernhofen, M. (2023). Enabling Data-Driven Investment in Adaptation and Nature: introducing the Resilient Planet Data Hub. Available at: https://www.eci.ox.ac.uk/news/enabling-data-driven-investment-adaptation-and-nature-introducing-resilient-planet-data-hub

Chapter 2

1. Draft Disclosure Framework on Climate-related Financial Risks, Reserve Bank of India, 2024, available here: https://www.rbi.org.in/Scripts/bs_viewcontent.aspx?Id=4393

2. The HEV framework is referred to in multiple market standard documents, including:

   i. Physical Climate Risk Assessment: Practical Lessons for the Development of Climate Scenarios with Extreme Weather Events from Emerging Markets and Developing Economies, NGFS, 2022, available here: https://www.ngfs.net/sites/default/files/media/2022/09/02/ngfs_physical_climate_risk_assessment.pdf

   ii. Climate Risk Management Framework for India, National Institute of Disaster Management, 2019, available here: https://nidm.gov.in/PDF/pubs/GIZ_NIDM_Climate%20RiskManagementFramework.pdf

   iii. Physical Climate Risk Assessment Methodology, Coalition for Climate Resilient Investment, 2021, available here: https://resilientinvestment.org/pcram/

Chapter 3

1. Climate Change 2022: Impacts, Adaptation and Vulnerability, IPCC, 2022, available here: https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf

Annex 8: References

Chapter 4

1. Bank regulation and disclosure to foster climate-related risk analysis, S&P Global, 2022, available here: https://www.spglobal.com/esg/insights/featured/special-editorial/bank-regulation-and-disclosure-to-foster-climate-related-risk-analysis
2. Financing India's Green Transition, Observer Research Foundation, 2023, available here: https://www.orfonline.org/research/financing-indias-green-transition-60753
3. Government's Borrowing plan for Second Half of FY 2023-24, Ministry of Finance, Press information Bureau, 2023, available here: https://pib.gov.in/PressReleasePage.aspx?PRID=1961016

Coalition for Disaster Resilient Infrastructure

Coalition for Disaster Resilient Infrastructure
4th & 5th Floor, Bharatiya Kala Kendra, 1, Copernicus Marg,
New Delhi–110001, India
Tel.: +91-11-4044-5999 | Email: info@cdri.world

www.cdri.world