



GLOBAL
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ADAPTATION



Handbook for Financial Institutions

Climate Adaptation Finance

Module 2



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In collaboration with:



European Bank
for Reconstruction and Development

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About the Global Center on Adaptation

The Global Center on Adaptation (GCA) is an international organization that promotes adaptation to the impacts of climate change. It works to accelerate action and support for adaptation solutions by shaping policy reforms and influencing investments made by international financial institutions and the private sector. The goal is to bring climate adaptation to the forefront of the global fight against climate change and ensure that it remains prominent. Founded in 2018, GCA ensures a continuous, two-way exchange of knowledge and best practices that empower communities and drive resilient and inclusive growth worldwide.

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The European Bank for Reconstruction and Development (EBRD) is a multilateral development bank founded in 1991 with a mandate to foster sustainable, well-functioning market economies. Its governance and mandate enable it to combine finance, policy support and capacity building – powerful tools for unlocking private investment and scaling adaptation finance in the financial sector.

The EBRD works closely with private-sector and public partners to complement its adaptation financing. The Bank has financed climate-resilient infrastructure in its regions, advanced nature-based solutions, and strengthened the management of physical risk across sectors. Through financial institutions, the EBRD channels green finance via hundreds of thousands of sub loans, an intermediation model that the Bank also leverages to expand adaptation lending.

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Module 2

Understanding Climate Change Science

What Financial Institutions Must Know

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The resulting Handbook reflects a **co-created approach**, shaped by valuable input and feedback from participating institutions. It draws on **real-world case studies**, **policy tools**, **financial instruments**, and **modelling techniques** relevant to FIs operating across both emerging and developed markets.

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Acronyms

CH₄	Methane
CO₂	Carbon Dioxide
CO₂-eq	CO ₂ equivalent
ECB	European Central Bank
EEA	European Environment Agency
ESG	Environmental, Social and Governance
EU	European Union
FI	Financial Institution
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GRASP	Geospatial Risk and Resilience Assessment Platform
GWP	Global Warming Potential
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
MSME	Micro, Small, and Medium-sized Enterprise
N₂O	Nitrous Oxide
NGFS	Network for Greening the Financial System
OECD	Organisation for Economic Co-operation and Development
RCP	Representative Concentration Pathway
SME	Small and Medium-sized Enterprise
SSA	Sub-Saharan Africa
SSP	Shared Socio-economic Pathway
TCFD	Task Force on Climate-Related Financial Disclosures
UNDRR	United Nations Office for Disaster Risk Reduction
USEPA	United States Environmental Protection Agency
WMO	World Meteorological Organization

Module Description

Module 2: Understanding Climate Change Science: What Financial Institutions Must Know

Description

Module 2 introduces the fundamentals of climate change, its transmission channels to the real economy and financial sector, and the implications for financial institution (FI) clients and portfolios. It explains how climate hazards affect clients directly through disrupted operations, assets, and income, and how FIs experience these risks indirectly through their portfolios when such impacts erode clients' abilities to repay. The module also highlights climate hazards and impacts on climate-vulnerable regions around the world, emphasising that challenges like data gaps, infrastructure exposure, and financing constraints are globally shared. By deepening understanding of climate risks across sectors and geographies, the module equips FIs with the insights needed to assess climate risk exposure on the portfolio and transaction level, setting the foundation to identifying commercially viable adaptation opportunities. This foundation supports the development of actionable strategies and investment pipelines explored in subsequent modules.

Target group

This Module is designed for a broad range of professionals involved in shaping, implementing, or communicating institutional strategy, product development, lending practices, and risk management within FIs. The Module is particularly relevant for professionals in the following functions:

- Executive Management; Strategy Department
- Sustainability/Environmental, Social and Governance (ESG) Department
- Risk Management (incl. Credit Risk, Operational Risk, Market Risk) and Compliance Departments
- Corporate/Wholesale, Small and Medium-sized Enterprise (SME) and Retail Banking Departments; Credit, Product and Structured Finance Departments
- Corporate Communications and External Affairs Department
- Public- and private-sector practitioners involved in identifying, developing and financing adaptation projects at national, regional or local levels.

Learning outcomes

Chapter 1: Introduction to Climate Science for Financial Institutions

- Explain why it is important for FIs to understand the basics of climate science
- Describe the main drivers of climate change
- Explain greenhouse gas trends and global warming pathways

Chapter 2: From Hazard to Vulnerability and Exposure

- Understand the climate risk framework, based on the combination of Hazard × Exposure × Vulnerability, and its applicability to FIs and their clients
- Recognise how understanding the risk components is fundamental for risk assessment

Chapter 3: Sectoral and Geographic Impacts of Climate Change

- Explore the impacts of climate change on economies, infrastructure, ecosystems, and communities
- Familiarise oneself with climate models and scenarios and their limitations

Chapter 4: Climate Risk Transmission Channels in the Financial Sector

- Distinguish between direct and indirect climate risk impacts on FIs
- Examine how adaptation investments (e.g., resilient infrastructure) mitigate credit, market, and operational risks
- Justify the need to integrate climate risk insights into long-term portfolio management

01

Introduction to Climate Science for Financial Institutions

FIs must first build a strong foundation in climate science to act effectively in the face of climate change. Understanding the scientific basis of climate change is essential for interpreting how changing climatic conditions increase the frequency and intensity of climate-related hazards such as droughts, floods and extreme weather, and how these changes create risks for people, assets and economic systems. It is particularly important for FIs to recognise that, while their clients face climate hazards directly, FIs are exposed indirectly through their portfolios when these impacts affect clients' operations, cash flows, and ability to repay.

This chapter addresses the following questions:

- **Why should FIs understand climate science?**
- **What are the key areas of competence in climate science for FIs to develop?**
- **What is climate change?**
- **Why is it important for FIs to understand what drives climate change for developing adaptation solutions?**



Target Group: Executive Management; Strategy Departments; Sustainability/ESG, Risk Management (incl. Credit Risk, Operational Risk, Market Risk) and Compliance Departments; Corporate/Wholesale, SME, and Retail Banking Departments; Credit, Product and Structured Finance Departments; and Corporate Communications and External Affairs Department.

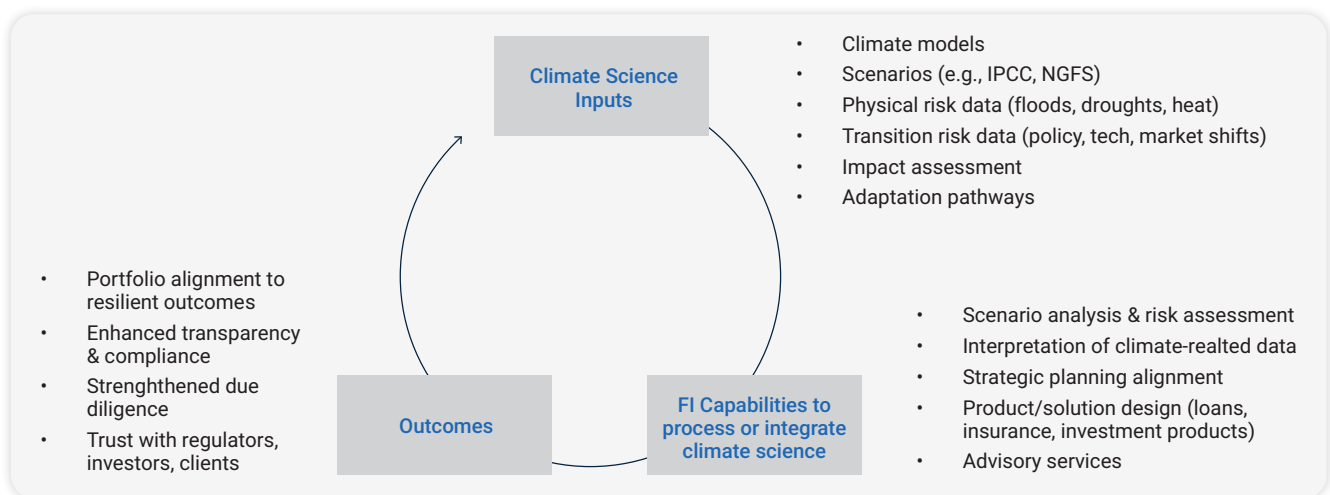
Importance of Climate Science

Why should FIs understand climate science?

FIs, especially in climate-vulnerable regions, must understand climate science to effectively manage risk, seize emerging opportunities, and meet evolving regulatory and market expectations (see **Figure 1**). Climate science, covering models, **scenarios, physical risks, transition risks**, impact assessments and adaptation pathways, provide the foundation for informed financial decision-making. When integrated,

these inputs enable FIs to strengthen capacities such as scenario analysis and risk assessment, strategic planning, client advisory, and the development of targeted financial solutions. These capabilities, in turn, support more resilient outcomes and lending decisions and guide clients and portfolios toward resilient outcomes.

Figure 1: Climate science as an enabler for financial institutions



Source: Authors.

At the same time, regulators, investors, and clients increasingly expect FIs to demonstrate credible climate competence. Embedding climate science into strategy enhances transparency, supports compliance and trust, and strengthens due diligence, product design, advisory services and performance

monitoring. These outcomes feed back into the system: stakeholders reinforce the need for deeper integration of climate science by raising expectations. This creates a continuous cycle in which climate science, institutional practice, and stakeholder demands mutually reinforce one another.

What are the key areas of competence in climate science for FIs to develop?

FIs need core climate science competencies to assess physical and climate-related transition risks, guide strategies, and identify adaptation investment

opportunities. These competencies range from understanding the drivers of climate change to applying **climate models** and scenarios for portfolio

planning (see **Table 1**). For example, “hazard–exposure–vulnerability” concepts help FIs evaluate how a flood event could impact their clients, collateral,

and credit risk. The remaining sections of this module explore each of these competence areas in more detail.

Table 1: Climate science competence areas for financial institutions

Competence Area	Topic	Rationale
Climate Change	Long-term shifts in temperature, precipitation, and extreme events driven by human activity	Provides the foundation for understanding why adaptation is necessary and how climate risks will evolve over time
Drivers of Climate Change	Greenhouse gas (GHG) emission sources (energy, transport, industry, land use, agriculture) and their atmospheric effects	Understanding the drivers of climate change helps FIs frame the underlying causes of climate hazards and recognise the limits of mitigation alone, reinforcing the need for adaptation alongside emissions reduction
Risk Concept	Definition of risk as the combination of hazard (climate event), exposure (assets/people affected), and vulnerability (sensitivity and adaptive capacity)	Equips FIs to understand the difference between climate risk to their clients and to their portfolio, as well as analyse how these risks translate into financial risks, supporting integration into credit, investment, and underwriting decisions
Physical Risk Data	Information on hazards such as floods, storms, droughts, sea-level rise and heatwaves	Enables assessment of exposure and vulnerability of assets, clients and portfolios to physical climate risks
Impact & Vulnerability	Sectoral and regional assessments of climate risks and adaptive capacity	Provides evidence for prioritising financing in vulnerable sectors/regions; informs credit, underwriting and investment decisions
Climate Models & Scenarios	Global/regional climate projections, emissions pathways, and Intergovernmental Panel on Climate Change (IPCC) scenarios	Enables stress testing and scenario analysis of portfolios under different warming outcomes; informs long-term planning
Transmission Risk Channels	Policy changes, carbon pricing, technology shifts, and shifts in consumer demand	Supports evaluation of how regulation and market shifts affect clients and sectors; identifies stranded asset risks and new opportunities

Source: Authors.

Causes of Climate Change

What is climate change?

According to the Intergovernmental Panel on Climate Change (IPCC, 2023), *climate change* can be defined as “...a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended

period, typically decades or longer”. These changes in climate conditions are not static and depend on natural climate variability and atmospheric changes caused by human activities (see **Figure 2**).

Figure 2: Drivers of climate change

Source: Authors.

Human-induced activities can also accelerate or intensify changes in patterns in climate conditions and are often observed over longer time periods (United Nations Environment Programme, 2024). Depending on how natural climate variability and atmospheric changes caused by human activities interact, this can lead to feedback loops in the climate system and exacerbate climate change even further. For example, El Niño is a natural phenomenon where the decrease in wind intensity leads to warmer waters in the Pacific and a combination of warmer and drier conditions in the Northern part of the USA and Canada, and wetter conditions in the Southern part of the USA and the Gulf of Mexico (National Oceanic and Atmospheric Administration, n.d.). It is one of the most important phenomena that controls the climate

and weather globally. Over the last few decades, it has increased in frequency and intensity due to negative feedback loops from natural climate variability and human-induced activities. Research from the United Kingdom's Meteorological Office indicates that when El Niño occurs, it can raise the temperatures across the globe by 0.2°C, which is just a fraction of the current global temperature increase of 1.3°C (UK Met Office, n.d.). This has significant implications for the patterns of precipitation, droughts, and storms across the African continent (Global Center on Adaptation [GCA], 2021), which can lead to losses in agricultural productivity, damages to infrastructure assets, disruptions in the generation and distribution of energy, among other impacts to economies, businesses, and people and communities.

Why is it important for FIs to understand what drives climate change for developing adaptation solutions?

Understanding the causes of climate change is essential for developing effective climate adaptation strategies because it helps FIs and decision-makers anticipate how future climate conditions may evolve and respond accordingly. The increase in GHG concentration and **emissions** in the atmosphere is the key driver of climate change. GHGs are gases that absorb and emit

heat, contributing to the greenhouse effect. They have different lifetimes in the atmosphere, which affects how they contribute to global warming. The main gas that causes this effect is CO₂ due to its long-lasting presence and significant impact on increasing the Earth's average annual temperature over time.

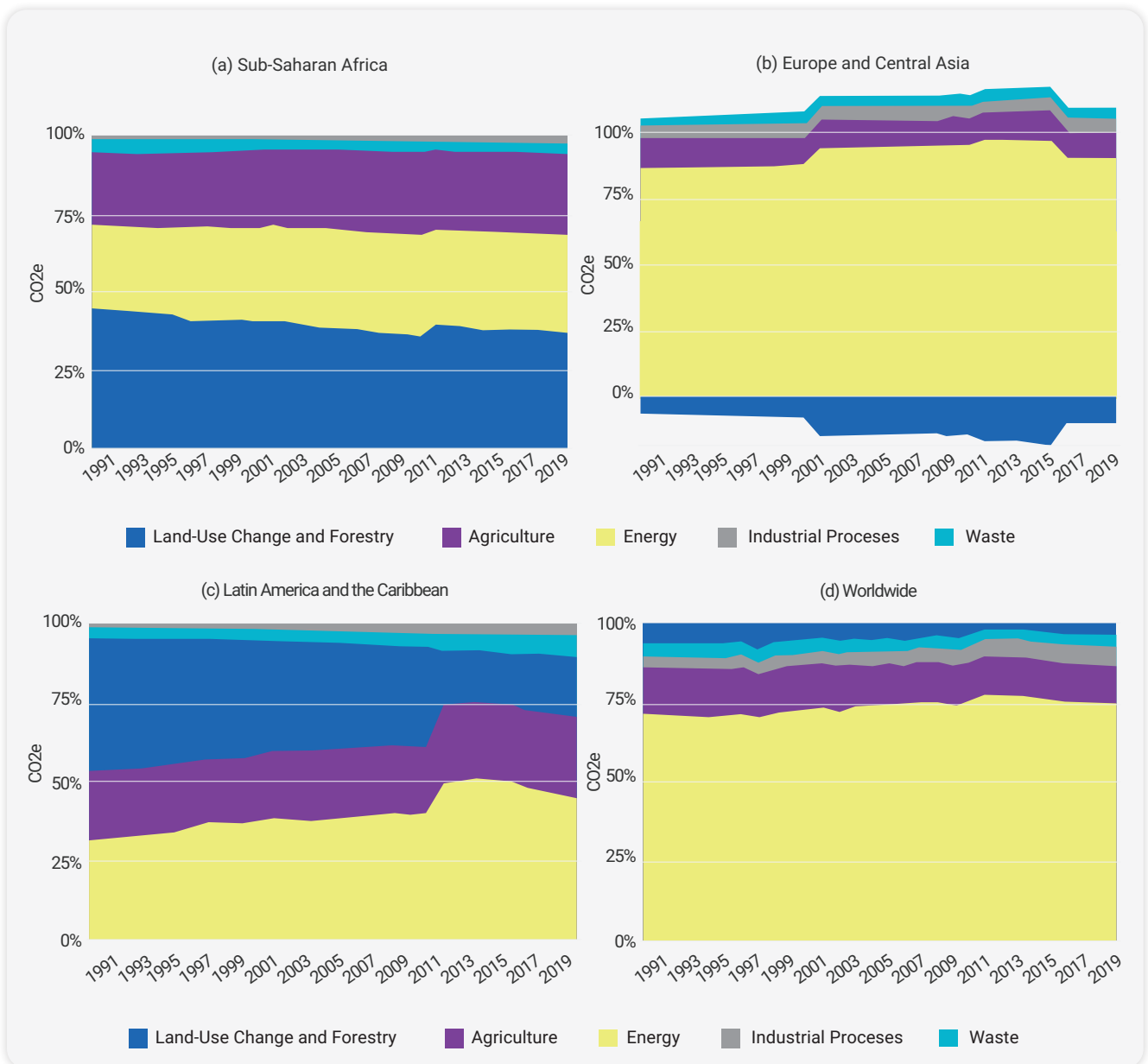
The emissions of GHGs occur in all economic sectors and anthropogenic activities. Examples include: **CO₂** from the combustion of fossil fuels, deforestation, and industrial processes, and changes in the balance of CO₂ due to vegetation loss and land use changes; **methane (CH₄)** from agricultural production, livestock, manure management, and from oil and gas production and distribution (Lau, 2022); and **nitrous oxide (N₂O)** from the use of nitrogen fertilisers in agriculture, (a byproduct of) fuel combustion, and wastewater treatment processes (United States Environmental Protection Agency [USEPA], 2025b). Furthermore, gases with fluor as a component are also important sources of GHG emissions and often result from the replacement of other ozone-depleting substances (e.g., refrigerants

from electrical appliances) and aluminium or semiconductor manufacturing (USEPA, 2025a).

Globally, emissions over the last decades were primarily from the energy, agriculture, and industrial sectors, although this is different across regions. For example, in Sub-Saharan Africa (SSA), the biggest contributing sectors are land-use change and forestry, agriculture and energy. Each of these sectors represents between 20 and 40% of total emissions in the region, and together, they reach a total of approximately 90% of total GHG emissions in SSA.

Figure 3 presents a comparison of GHG emissions per sector across SSA, Europe and Central Asia, Latin America and the Caribbean, and Worldwide.



Figure 3: Historical greenhouse gas emissions per sector across geographies

Source: World Resources Institute (2023).

For FIs, understanding the sources of GHGs and sectors that contribute the most to these emissions in the relevant geographies is an important step toward understanding the different dimensions of climate risk. This knowledge helps FIs to assess their **exposure** and vulnerabilities to climate **hazards**, develop better

climate risk management strategies, and design appropriate adaptation measures to reduce climate risks to their clients and the institution's portfolio, with potential mitigation co-benefits. Each of the dimensions of climate risk is detailed in the next Chapter.

02

From Hazard to Vulnerability and Exposure

Building on the previous chapter's overview of climate change and its causes, this chapter introduces FIs to the definition of climate-related risk: **Risk = Hazard × Exposure × Vulnerability**. It connects climate science to climate risk analysis by explaining how this equation serves as a foundational tool for identifying and evaluating both physical and transition risks (which is detailed in the later chapters of this module). Furthermore, it makes the distinction between climate risks to FI's portfolio and to their clients.

This chapter addresses the following questions:

- **What are climate risks?**
- **What are climate hazards?**
- **How are climate hazards expected to change in the future?**
- **What determines the impacts of climate hazards?**
- **What are the different types of vulnerabilities related to climate hazards?**
- **How are FIs' portfolio and their clients impacted by client risks?**



Target Group: Executive Management; Strategy Department; Sustainability/ESG Department; Risk Management (incl. Credit Risk, Operational Risk, Market Risk) and Compliance Departments; Corporate/ Wholesale, SME, and Retail Banking Departments; Credit, Product and Structured Finance Departments.

Understanding the Climate Risk Framework

What are climate risks?

Climate risks refer to the potential adverse impacts of climate change on assets, operations, and financial systems. Technically, climate risk is a function of three interrelated components: Hazard × Exposure × Vulnerability. For example, consider an FI with a significant portfolio in small manufacturing firms located in a coastal industrial zone. The increasing frequency of coastal flooding represents a **hazard**. These firms are exposed because their facilities and supply routes are situated in low-lying areas. Their **vulnerability** is heightened by limited flood-protection measures, inadequate insurance, and dependence on uninterrupted operations. When a major flood occurs, clients face direct physical and business interruption risks, reducing their ability to generate revenue and repay loans. The FI, in turn, experiences indirect credit risk as these impacts

flow through to its portfolio. This framing reflects that risk is not solely determined by the presence of climate-related hazards (e.g., extreme weather events or gradual temperature rise), but also by the degree to which assets or systems are exposed to these hazards, and how susceptible they are to damage or disruption. For FIs, applying this framework enables a more robust and nuanced assessment of climate-related risks. It supports informed decision-making by helping institutions evaluate potential impacts on their investments, design targeted adaptation and mitigation strategies, meet regulatory requirements, allocate resources more effectively, and strengthen their market position through a demonstrated commitment to climate **resilience** and sustainability. **Box 1** defines key climate change concepts that underpin this risk framework.

Box 1: Definition of climate risk components

Hazard is the “potential occurrence of a natural or human-induced physical event or trend 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” (IPCC, 2023). Examples of climate-related hazards include extreme temperatures, extreme winds, flooding (fluvial, pluvial and coastal), heat stress, water stress, drought, wildfires, and rainfall-triggered landslides. Climate hazards can lead to climate risk. Also important is to distinguish climate-related hazards from natural hazards, such as earthquakes, volcanoes, and tsunamis, which are not caused by climate change and do not lead to climate risk.

Exposure is “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” (IPCC, 2023). Infrastructure, economies, and populations will be exposed to climate hazards if they are located in areas prone to the occurrence of hazard events, such as industries built in coastal areas prone to flooding or people inhabiting areas with high landslide hazards.

Vulnerability is “the propensity or predisposition to be adversely affected and encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt” (IPCC, 2023). Vulnerability can be expressed as the combination of sensitivity and adaptive capacity. Sensitivity represents relationship between the intensity of a hazard event and the degree of damage or loss it causes to infrastructure, economies and populations exposed to these hazards (e.g., livelihoods based on agriculture are highly sensitive to climate-related drought); while adaptive capacity represents the ability of people, institutions, and systems to respond to or withstand hazardous events (e.g., industries adjusting work schedules to deal with extreme heat days and reduce health risks to workers).

Examples of vulnerability are:

- **Physical:** Low-lying areas prone to flooding, poorly constructed buildings.
- **Social:** High population density, particularly in low-income neighbourhoods with limited access to resources.
- **Economic:** Dependence on coastal tourism and fishing industries, which are highly susceptible to flood damage.
- **Environmental:** Dependence of ecosystems (e.g., coral reefs and wetlands) on temperature, water/sea level, and weather patterns, which are changing due to climate change.
- **Institutional:** Limited emergency response capacity procedures or awareness of the population on how to act when a hazardous event occurs.

Risk is “the potential for adverse consequences where something of value is at stake and where the occurrence and degree of an outcome is uncertain”. Within the context of climate change, climate risk refers to potential negative impacts resulting from the interaction of three components: Hazard x Exposure x Vulnerability. Climate risk only materialises when a climate-related hazard (e.g., flood, drought, heatwave) occurs in an area where assets or systems are exposed and vulnerable to its effects, resulting in damage, disruption, or loss.

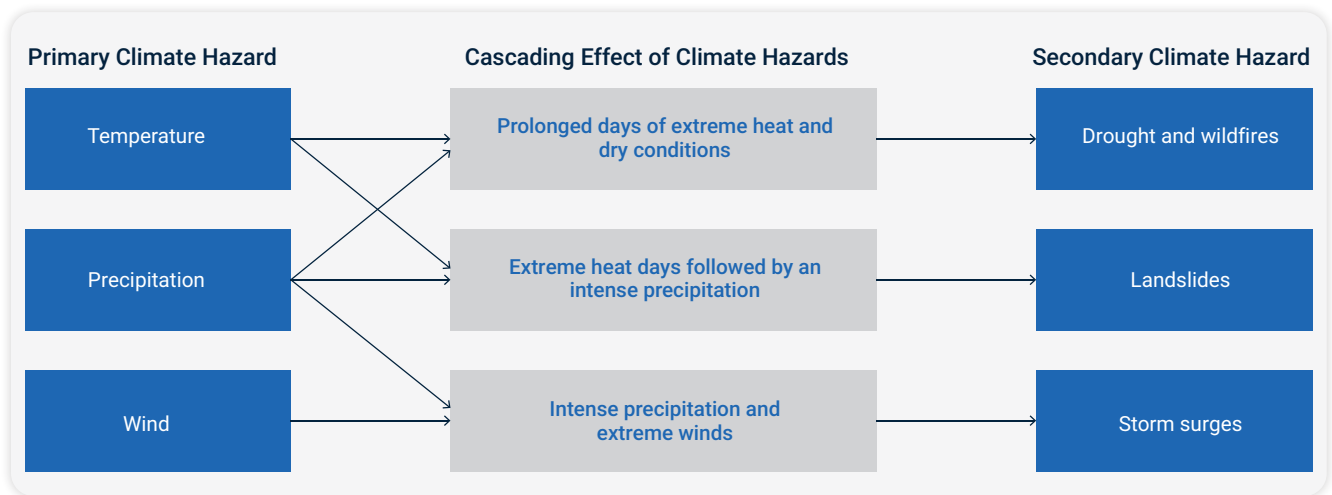
According to the Task Force on Climate-Related Financial Disclosures (TCFD), climate risks can be distinguished between physical climate risks and transition-related climate risks (TCFD, 2017). The definition of physical climate risks is presented in this chapter, while the definition of transition-related climate risks is presented in Chapter 4.

Physical climate risks are the risks associated with physical damage to infrastructure assets or losses and supply-chain disruptions to economies and people. These damages, or losses and disruptions, can result from **acute physical risks** when extreme hazard events occur (e.g., hurricanes and tropical cyclones) or **chronic physical risks**, slow-onset changes to climatic conditions (e.g., sea level rise and global warming).

What are climate hazards?

Climate hazards are the hazards that result from extreme weather events and gradual shifts in climate. For example, changes in precipitation patterns may cause river systems to dry up or flood permanently, melting glaciers will lead to sea level rise and accelerate coastal erosion processes, and extreme temperatures may extinguish coral reefs. The occurrence of primary climate hazards, such as

extreme temperatures, intense precipitation events, and strong winds, can also trigger secondary climate hazards, such as droughts, wildfires, landslides, and storm surges. It is important to understand this interaction because the occurrence of climate hazards can also lead to wider cascading impacts to people, the economy, and ecosystems that might be difficult or impossible to reverse (see **Figure 4**).

Figure 4: Examples of primary and secondary climate hazards

Source: Authors.

How are climate hazards expected to change in the future?

Climate change does not refer to immediate or short-term changes like the weather conditions on a day. Rather, changes in climate need to be analysed with a longer-term perspective to assess how patterns of wet or dry periods across seasons are shifting, how temperatures are increasing globally, and how the overall **climate system** is changing. Human-induced activities are causing significant changes to climate conditions, altering natural climate cycles, and making natural and climate events more intense and frequent.

As climate hazards can be observed through extreme-weather events (i.e., for acute hazards such as tropical storms) and slow-onset changes to climate patterns (i.e., for chronic hazards such as sea level rise), proper measurement of climate indicators and consideration in planning, strategies and solutions need to be adopted. The variability of climate change and its increasing impacts illustrate the uncertainty of how climate conditions are going to evolve in the future.

Examples of climate hazards and how they can be measured are:

- **Extreme temperatures:** An increase in the number of days above 35°C or 40°C, as well as consecutive extreme heat days.
- **Extreme precipitation:** The mean annual rainfall or daily maximum rainfall.
- **Drought:** The combination of an increase in temperatures and reduced annual rainfall, which can exacerbate drought conditions.
- **Flooding:** More intense and frequent precipitation events, leading to increased flooding, which is exacerbated by sea level rise.

These hazards will not increase or decrease the same way across geographies. **Figure 5** shows how climate hazards are expected to evolve across the world and the level of confidence (or uncertainty) of change for different climate variables.

Figure 5: Key climate hazards for different regions across the world

Climatic Impact-driver																												
Heat and Cold				Wet and Dry						Wind				Snow and Ice				Coastal and Oceanic				Other						
Mean air temperature	Extreme heat	Cold spell	Frost	Mean precipitation	River flood	Heavy precipitation and pluvial flood	Landslide	Aridity	Hydrological drought	Agricultural and ecological drought	Fire weather	Severe wind storm	Tropical cyclone	Sand and dust storm	Snow, glacier and ice sheet	Permafrost	Lake, river and sea ice	Heavy snowfall and ice storm	Hail	Snow avalanche	Relative sea level	Coastal flood	Coastal erosion	Marine heatwave	Ocean and lake acidity	Air pollution weather	Radiation at surface	Atmospheric CO ₂ at surface
Africa																												
North Africa	↗	↗***	↘***					↗	↗	↗		3									↗	4	↗	↗	↗		↗	
Sahara***	↗	↗**	↘***																		↗	4	↗	↗	↗		↗	
Western Africa	↗	↗**	↘***	1	↗			↗ ¹	↗ ¹	↗ ¹											↗	4	↗	↗	↗		↗	
Central Africa	↗			↘ ^{1,2}						↗											↗	4	↗	↗	↗		↗	
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Madagascar	↗	↗	↘										3								↗	4.5	↗	↗	↗		↗	
Asia																												
Arabian Peninsula	↗	↗***	↘***	↘																	↗	1	↗	↗	↗		↗	
West Central Asia	↗	↗***	↘***	↘	5	↗		↗		↗		↘			↗						↗	1.2	↗	↗	↗		↗	
West Siberia	↗	↗***	↘***	↘	↗	↗						↘			↗												↗	
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Russian Far East	↗	↗***	↘***	↘	↗	↗									↗						↗	1.2	↗	↗	↗		↗	
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East Central Asia	↗	↗***	↘***	↘		↗				↗		↘			↗												↗	
Tibetan Plateau	↗	↗***	↘***	↘		↗						↘			↗												↗	
South Asia	↗	↗***	↘***	↘	↘	↗						↘			↗						↗	1	↗	↗	↗		↗	
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Europe																												
Mediterranean	↗	↗***	↘***		↘	5			↗	↗		↘ ⁶	7		↘						↗	2	↗	↗	↗		↗	
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Eastern Europe	↗	↗***	↘***	↗	↗	↗						↘			↗												↗	
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North Central America	↗	↗**	↘**					↗													↗	2	↗	↗	↗		↗	
Western North America	↗	↗**	↘**	3	5	5	4.7		↗ ^{6,7}	↗ ^{6,7}	↘	8		↗ ⁶	↘ ¹	↘	1		1	↗	5	2	↗	↗	↗		↗	
Central North America	↗			↗	↗**		7		7	7	↘	8		4	↘		↘				↗	2	↗	↗	↗		↗	
Eastern North America	↗			↗ ⁵	↗					7	↘	8			↘ ¹		↘		1	1	↗	2	↗	↗	↗		↗	
North-Eastern North America	↗	↗***	↘***	↘	5			5		6.7	6.7	8			↘ ^{1,6}	↘	↘		1	4	↗ ^{4,6}	2.6	↗	↗	↗		↗	
North-Western North America	↗	↗***	↘***	↘	5		6	5		6.7	↗ ^{6,7}	8			↘ ¹	↘	↘		1.6	↗ ⁹	2	↗	↗	↗		↗		

Key for observational trend evidence ↗ Past upward trend (medium or higher confidence) ↘ Past downward trend (medium or higher confidence)
Key for attribution evidence *** High confidence (or more) ** Medium confidence

Key for level of confidence in future changes

High confidence of increase (or more)	Medium confidence of increase (or more)	Low confidence in direction of change	Medium confidence of decrease	High confidence of decrease	Not broadly relevant
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Note: More details on assumptions and limitations of the indicative trends, noted by the numbers (1-7) in the cells, are provided in the Contribution of Working Group I to the Sixth Assessment Report of the IPCC.

Source: Adapted from IPCC (2021).

Impacts of Climate Hazards

What determines the impacts of climate hazards?

The key factors that contribute to determining the impact of climate hazards are intensity, frequency and duration, as described below.

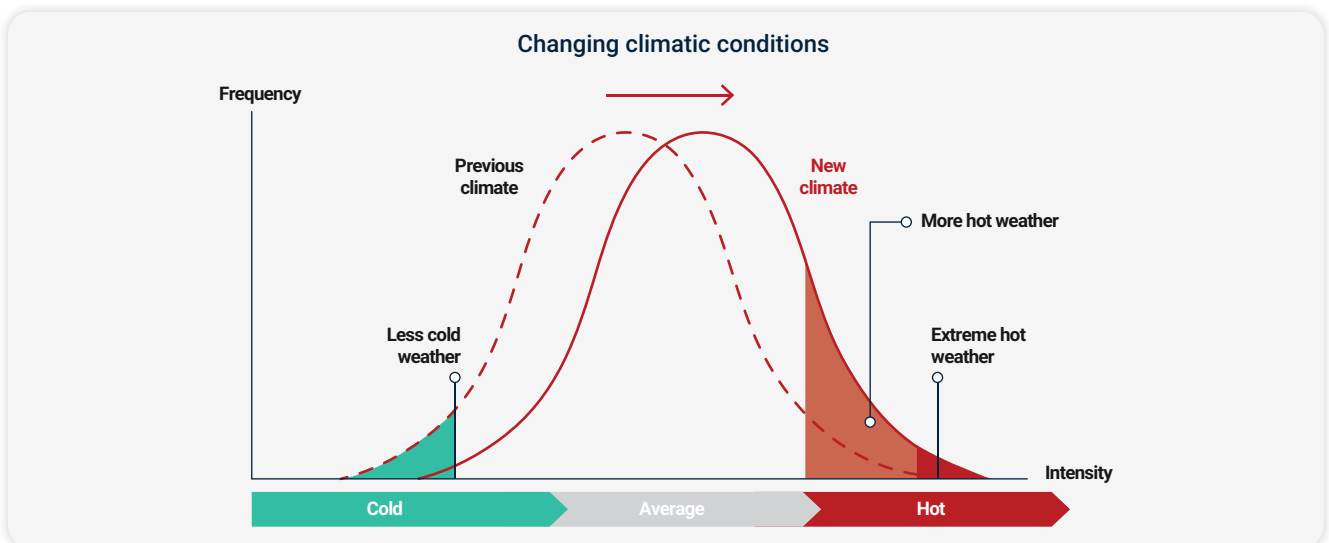
→ **Intensity:** Quantify the increase or decrease in the measurement of a climate indicator, such as the number of days above a certain temperature or millimetres of precipitation.

→ **Frequency:** Assess how often these impacts occur, considering historical data and future projections

→ **Duration:** Determine the length of time the impacts persist, from immediate effects to long-term consequences

Figure 6 shows how changes in climate conditions can increase the intensity and frequency of climate hazard events, more specifically, a slightly warmer climate can already lead to a much greater number of hot days in a year.

Figure 6: Overview of how changes in climate conditions can affect the intensity and frequency of hazard events



Source: Adapted from British Broadcasting Corporation (2024).

Climate scenarios (described later in this Module) aim to represent possible future scenarios of climate conditions depending on how atmospheric changes will evolve based on emissions from human activities, whether (global) climate policies and targets will be met or not, and how quickly we can implement both climate **adaptation** and **mitigation** solutions. It is

important to recognise that even if the **GHG** emissions were halted entirely, global temperatures would continue to increase for decades (Massachusetts Institute of Technology, 2023). In other words, climate mitigation alone is not sufficient to fully address the impacts of climate change; climate adaptation must complement climate mitigation efforts.

What are the different types of vulnerabilities related to climate hazards?

Vulnerability refers to how the economy and infrastructure, nature and biodiversity, and people and communities are impacted by climate hazards, and

their capacity to adapt and respond to these events.

Examples of vulnerabilities are shown in **Table 2**.

Table 2: Description of types of vulnerabilities to climate change

Type of Vulnerability	Description	Implications for Financial Institutions
Physical Vulnerabilities	Weaknesses in structures or locations (e.g., buildings in flood-prone areas).	Must be considered when financing infrastructure projects.
Financial Vulnerabilities	Limited access to capital (e.g., low-income communities with few resources).	FIs can provide targeted support, such as low-interest loans, to promote adaptation and recovery.
Economic Vulnerabilities	Sectoral dependence (e.g., agriculture-based economies vulnerable to climate change).	FIs can provide sector-specific approaches to promote adaptation and resilience of their client base.
Environmental Vulnerabilities	Sensitivity of natural systems (e.g., water scarcity in watersheds, reducing availability for consumption).	FIs should consider environmental impacts and invest in ecosystem preservation or resilience.
Social Vulnerabilities	Social characteristics of populations (e.g., dependency on specific activities for livelihoods).	Affect risk-sharing and access to resources; FIs can assess community resilience.
Institutional Vulnerabilities	Weak governance and institutional capacity (e.g., lack of uptake of digital climate advisory services).	FIs can play a role in strengthening institutions through financing, technical assistance, and advocacy efforts.

Source: Authors.

How are FIs' portfolios and their clients impacted by climate risks?

Clarifying the distinction between climate risk at the client level and climate risk at the FI portfolio is key. From the client side, physical climate risks relate to damage and disruptions to the borrower's assets, operations, productivity, and cash flow. These effects increase the client's probability of default and reduce collateral values, ultimately affecting loan repayment capacity. From the FI side, physical climate risks arise

primarily through the portfolio when such client-level impacts indirectly affect credit risk, capital adequacy, and balance sheet resilience, particularly when multiple clients experience climate impacts simultaneously. It also includes physical risks to the FI's own infrastructure and operations, which may also occur, although this is less relevant in the context of financing adaptation solutions.

Translating this distinction into practice, FIs can already begin assessing climate risks within the existing portfolio and in credit and risk processes. Practical steps include screening portfolio exposure using publicly available hazard maps or climate-risk dashboards; identifying vulnerable borrower segments (e.g., SMEs in flood-prone areas or logistics firms exposed to extreme heat); integrating a limited number of climate-related questions into credit assessments (e.g., past climate-related damages or frequency of disruptions); and flagging material geographic, sectoral, or hazard concentrations that may influence the bank's credit risk profile. These insights can help inform lending strategies, product design, and prioritisation of adaptation investments, as discussed in Module 3. By improving their understanding of client vulnerabilities to climate hazards and taking actions to reduce them, FIs

support their clients in managing climate risks, while reducing the exposure of their own portfolio.

This analysis can help FIs to identify material risks, geographic or sectoral concentrations across their portfolio, and areas where clients may require additional information or support. These insights will form the basis for a robust, climate-informed investment strategy to manage risks. The adaptation solutions that could be part of this strategy and applicable to different hazards, vulnerabilities, sectors, and types of clients are further discussed in Module 4 of this Handbook. Throughout this assessment, FIs and their clients would need to engage with other local institutions and stakeholders to deepen their understanding of climate vulnerabilities (Principles for Responsible Investment, 2025).


03

Sectoral and Geographic Impacts of Climate Change

Climate impacts affect economies and infrastructure through economic losses and damages to assets; natural systems and biodiversity through the degradation of the natural environment and the loss of ecosystem services; and people and communities through adverse health outcomes, deaths, displacement, and loss of livelihoods. These impacts are not felt equally across geographies, economies and sectors. Furthermore, the level of climate risk in the future will depend on the mitigation and adaptation actions taken and which global warming scenario we are heading towards.

This chapter addresses the following questions:

- **What are the global impacts of climate hazards?**
- **What are the impacts on economies, nature, and societies?**
- **How will climate impacts change in the future?**
- **Why are climate change impacts hard to predict?**
- **How to measure future climate conditions?**
- **What are climate scenarios and how they differ from climate models and climate projections?**
- **What types of global climate scenarios exist?**
- **What are the limitations of climate scenarios?**
- **How does data quality impact climate model outputs, and how can it be improved?**

 **Target Group:** Sustainability/ESG Department; Risk Management (incl. Credit Risk, Operational Risk, Market Risk) and Compliance Department; Credit, Product and Structured Finance Departments.

Impacts of Climate Risks

What are the global impacts of climate hazards?

Impacts can be defined as the “consequences of realized risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather/climate events), exposure, and vulnerability” (IPCC, 2023; United Nations Climate Change, n.d.; Climate Impacts Group, 2021). The magnitude of direct or indirect impacts, such as economic losses, human casualties, or environmental degradation, will, therefore, depend on the occurrence of a hazard, exposure to this hazard, the vulnerability (or capacity to respond to its occurrence), and the damage incurred.

According to the World Meteorological Organization (WMO), between 1970 and 2019, there were a total of 11,072 disaster events worldwide attributed to weather, climate, and water hazards, which caused more than 2 million deaths and US\$ 3.64 trillion in economic losses, 37% of which occurred only in

the period between 2010 and 2019 (WMO, 2021). Between 2021 and 2023, estimates show that losses amounted to US\$ 280 billion (MunichRe, 2024). Low and lower-middle-income economies are particularly affected, with climate and natural hazard-related losses accounting for 0.8% to 1.0% of **gross domestic product (GDP)** on a yearly basis (United Nations Office for Disaster Risk Reduction [UNDRR], 2022). The observed growth in the impacts of climate events is due to both the more intense and frequent events, as well as the increase in economic development and assets exposed to these events. However, these impacts of climate change are not felt equally across geographies, economies, and sectors. **Table 3** outlines examples in the African continent to which FIs and their clients were exposed. Module 4 takes a deeper dive into climate hazards and risks, as well as adaptation solutions, across multiple sectors and geographies.

Table 3: Example of exposure by sector

Sector	Example
Agriculture	In Sudan, below-average rainfalls and prolonged dry spells resulted in a forecasted decrease in sorghum and millet production by about 25% and 50%, respectively, compared to 2022 (WMO, 2024a).
	Since 2017, Tunisia has experienced a reduction of water reservoir levels by half, reducing the productivity of livestock and escalating agricultural production costs (Meddeb, 2025).
Forestry	More than 100 wildfires were recorded in north-eastern Algeria in August 2022 leading to at least 44 deaths, the evacuation of 2,000 people from their homes, and the burning of 6,000 hectares of forest (International Federation of Red Cross and Red Crescent Societies).
	Ghana is losing 120,000 ha of forest annually (~35% coverage), particularly driven by agriculture, logging and mining activities. This can lead to challenges in water regulation, biodiversity degradation, and loss of livelihoods (Ghana News Agency, 2025).
Energy	In Tanzania, prolonged droughts have caused adverse economic impacts, including the reduction in hydropower capacity, with hydropower accounting for ~37% of electricity generation capacity. Dry spells in 2015 led to a near cessation of the Mtera Dam (International Monetary Fund [IMF], 2023).

Sector	Example
Energy	In Morocco, average annual temperatures have increased by over 2°C in cities such as Ojuda, Taza, Errachidia and Beni Melal, and this increase is more prominent in the dry season. Hotter temperatures can strain the energy systems to supply the demand for cooling (International Environment Agency, 2023).
Transport	In 2021, Egypt experienced some of the hottest weather in the past 50 years. For several weeks, temperatures were up to 7°C above average, along with high humidity. Temperatures exceeded 40°C in many areas and up to 47°C. Cairo experienced power outages and several closures of the metro transport system (Mikhail G., 2021). In Kenya, fluctuations in rainfall and temperature are increasing the occurrence of flooding events and erosion on roads, rail, and transport infrastructure, disrupting connectivity and trade activities along key transport corridors (Nying'uro et al., 2024).

Source: Compiled by authors.

What are the impacts on economies, nature, and societies?

Climate impacts affect economies and infrastructure through economic losses and damages to assets; natural systems and biodiversity through the degradation of the natural environment and loss of ecosystem services; and people and communities through adverse health outcomes, deaths, displacement, and loss of livelihoods. The impacts of climate change affect people and cause economic losses, leading to indirect impacts, such as disruptions to business and supply chains and deterioration of ecosystems (Organisation for Economic Co-operation and Development, 2024), which in turn can lead to 'feedback loops' or the situation where climate

impacts get "stronger or weaker, starting a cyclical chain reaction that repeats again and again" (The Climate Reality Project, 2020).

Table 4 illustrates impacts on economies, nature, and society, while **Table 5** presents a non-exhaustive list of impacts that natural and climate risks have on the economy and infrastructure, nature and biodiversity, and people and communities. These impacts can be even more severe when combined with population and (uncontrolled) urban growth, economic development and other societal changes.

Table 4: Examples of impacts on economies, nature and society

Examples of impacts on economies and infrastructure
<ul style="list-style-type: none"> In 2019, low water levels in the Kariba Dam in Zimbabwe led to a loss of US\$ 200 million in energy production and caused several power shortages (Banya, N., 2019). Increased rainfall variability is likely to affect electricity prices in countries with a high dependency on hydropower (Trisos et al., 2022). Across Africa, one study estimates cumulative costs to 2100 to repair and maintain existing road networks damaged from climate change-related precipitation and temperature changes at US\$ 183.6 billion (with adaptation) to US\$ 248.3 billion (without adaptation) (Trisos et al., 2022).

- In the UK, heatwaves in 2006 disrupted the energy and agriculture sectors and caused market swings; significantly colder temperatures in 2010 and 2011 led to an increase in the consumption of energy and supply chain disruptions, affecting the stock market and causing instability (Ahmed et al., 2024).
- Economic losses due to climate change in European Union (EU) member states have reached EUR 208 billion between the period of 2021 and 2024 (European Environment Agency [EEA], 2025).

Examples of impacts on nature and biodiversity

- A 1-2°C increase in sea temperature can cause corals to bleach and eventually extinguish if prolonged. Reef degradation leads to declines in fish populations due to loss of breeding and feeding grounds.
- In Jamaica, without mangrove protection, residential and industrial property damages would rise by 24% (World Bank, 2019), which can lead to an increase in insurance claims.
- Montane forests are expected to lose 47-64% of their suitable habitat extent by 2085 under the **representative concentration pathway (RCP)** 4.5 and RCP 8.5 scenarios, respectively, while microhabitat forests could lose more than 70% of their habitat. Woodland vegetation, the country's most extensive forest type, could lose close to 5% of its suitable habitat (World Bank, 2024).
- The Baltic Sea Region is suffering from a decrease in ice cover season, which has reduced by 14-44 days and is expected to reduce up to 2-3 months in future climate projections (EEA, n.d.).

Examples of impacts on people and communities

- Around the same period, floods across Eastern Africa led to the displacement of 500,000 households, over 11,000 livestock deaths, the destruction of 25,000 hectares of cropland, and placed 3.4 million people in acute food insecurity (WMO, 2024b).
- The increase in extreme temperatures in North Africa, including in 2021 when Egypt registered 47°C, led to unsafe health conditions for workers, unbearable heat for the population in urban areas, and the shutdown of Cairo's metro system (Mikhail G., 2021).
- In May 2024, the state of Rio Grande do Sul in Brazil suffered unprecedented rainfall affecting over 2.3 million people, displacing 630,000 households and disrupting rice supply and artisanal fishing activities (WMO, 2024b).
- Natural disasters are affecting 1.4 million people in Uzbekistan and 500,000 in Kazakhstan and Tajikistan (Times of Central Asia, 2025).

Source: Authors.

How will climate impacts change in the future?

The level of climate risk in the future will depend on the mitigation and adaptation actions taken and which global warming scenario is unfolding. Under a high emissions scenario without adaptation actions, the areas affected by flooding worldwide are expected to increase up to 64% by 2100 in comparison to current levels, and 14% of global port operations are expected to be at high risk for multiple hazards by 2100 in comparison to 4% currently, and usable hydropower could reduce up to 74% by 2069 (Organisation for Economic Co-operation and Development [OECD], 2024). Infrastructure investors could suffer a 27% loss in their net asset value across sectors. Transport, energy, and water are the most affected

sectors, reaching up to 97% and 40% loss, respectively, under the most extreme physical risk scenario produced by the Network for Greening the Financial System (NGFS) (École des Hautes Études Commerciales du Nord, 2023).

Overall, the global economy is projected to suffer a loss of 18% of GDP by 2050 on a business-as-usual scenario where global temperatures could rise by 3.2°C. However, if all targets and actions from the Paris Agreement are met, this could be significantly lower, only 4.2% (SwissRe, 2021). Under more extreme climate conditions, Africa could lose 30% of the harvestable areas for maize and banana, and 60% for

beans by 2050 (Rippke U. et al., 2016). These crops are critical for the livelihoods of the population.

The message is clear: the impacts of climate change cause material risks to economies, businesses, and populations, and are only expected to worsen in the future. Climate projections increasingly suggest that limiting global warming to 1.5°C above pre-industrial levels, as envisaged under the Paris Agreement, is ever

more unlikely. This makes it more critical to accelerate both mitigation measures to limit global warming and stay well below 2.0°C, and adaptation measures to manage and reduce the consequential physical impacts. As a result, evaluating climate risks and potential losses is essential for ensuring the long-term viability of risk-sharing mechanisms between the public and private sectors and for maintaining the financial sustainability of investments.

Table 5: Overview of impacts of climate and natural hazards on economy and infrastructure, nature and biodiversity, and people and communities

Climate Hazards	Impacts on Economy and Infrastructure	Impacts on Nature and Biodiversity	Impacts on People and Communities
Extreme Temperatures	<ul style="list-style-type: none"> Higher demand for cooling in buildings and data centres, leading to increased energy consumption. Degradation and deterioration of equipment and infrastructure, leading to higher replacement and repair costs. Increased strain on water treatment systems due to reduced water inflow quality. Buckling of railway lines leading to downtime in the transport of goods. 	<ul style="list-style-type: none"> Shortened growing season for some crops, impacting the harvest yield. Crop deterioration or death due to lack of water availability and reliance on crop irrigation. Heat-related illness of livestock and an increase in pests and invasive species. Higher water evaporation loss in reservoirs, leading to shortages in energy generation or supply. Reduced water oxygen levels, leading to the death of aquatic life. 	<ul style="list-style-type: none"> Increase the heat stress of employees working outdoors. Spread of vector-borne diseases and loss of health quality. Unbearable heat, leading to unhealthy work conditions and even the risk of death by dehydration. Reduced ability to work, leading to financial losses for households.
Drought	<ul style="list-style-type: none"> Cracking and internal erosion of dams. Lower water levels can reduce vessel capacity in ports and waterways. 	<ul style="list-style-type: none"> Reduced availability of water resources, including surface and groundwater. Crop failure, decline in yields, and reduction in harvested areas (loss of agricultural productivity). Drier vegetation and reduced soil moisture, which can lead to wildfires. Lower water levels can allow saltwater to move upstream, causing saltwater intrusion issues. 	<ul style="list-style-type: none"> Reduced availability of potable water for consumption. Food insecurity and loss of livelihoods. Impacts on water-based tourism due to increased occurrence of drought.

Climate Hazards	Impacts on Economy and Infrastructure	Impacts on Nature and Biodiversity	Impacts on People and Communities
Wildfires	<ul style="list-style-type: none"> Burning of transmission lines and poles. Damages to houses and buildings. 	<ul style="list-style-type: none"> (Irreversible) damage to forests and loss of biodiversity. Decreased timber supply, impacting the supply chain and increasing consumer prices. 	<ul style="list-style-type: none"> Loss of properties and livelihoods. Health impacts due to the inhalation of smoke.
Extreme Precipitation	<ul style="list-style-type: none"> Overtopping of reservoirs and malfunctioning of spillway gates, leading to disruptions in the energy supply. Overwhelming drainage and wastewater infrastructure, potentially washing away road assets. High humidity due to precipitation affects the quality of mineral production, including iron ore. 	<ul style="list-style-type: none"> Increased sedimentation in reservoirs and water bodies. Mudflows caused by intense precipitation can degrade soil and land. Runoff, including fertilisers and pesticides, impacts water quality. 	<ul style="list-style-type: none"> Shorter to longer periods without access to electricity (i.e., power outages).
Flooding (fluvial, pluvial, or coastal)	<ul style="list-style-type: none"> Damage to physical assets (e.g., buildings, shops, equipment). Reduced property value due to the increasing risk of inundation. Collapse of sewerage systems and water treatment facilities. 	<ul style="list-style-type: none"> Soil erosion reduces soil nutrients and impacts root stability. Change in the coastal equilibrium profile, advancing coastal erosion processes and degrading shorelines. Crop losses due to flooding of agricultural fields. Sea level rise can push saltwater inland and cause contamination of freshwater resources. 	<ul style="list-style-type: none"> Sea level rise can lead to the displacement of entire communities. Disruption in the access to schools, hospitals, and essential goods. The occurrence of events may lead to the relocation of people.
Extreme Winds	<ul style="list-style-type: none"> Extreme winds damage utility lines, cutting off access to communication and energy, shutting down industries. Damages to manufacturing, warehouses, and distribution facilities, leading to increased insurance costs. 	<ul style="list-style-type: none"> Increase in atmospheric humidity and circulation. Damage to forests. 	<ul style="list-style-type: none"> Loss of communication and access to the internet. Shortages in food and water. Psychological impacts due to the devastating losses suffered.

Measurement of Future Climate Conditions

Why are climate change impacts hard to predict?

The severity of impacts poses the threats described in the previous chapter and can lead to compounding or cascading impacts that are complex to predict and often have wider (in spatial extent and reach) or even more devastating (in intensity) impacts. *Cascading impacts* can be defined as “...the impact of a physical event or the development of an initial technological or human failure generates a sequence of events in human subsystems that result in physical, social, or economic disruption” (Pescaroli and Alexander, 2017). These complex interactions between climate systems and human activities create uncertainty about climate impacts, as predicting the exact consequences of climate change on ecosystems, economies and societies involves many variables and assumptions. Recognising and understanding these uncertainties is critical to avoiding **maladaptation** (UNDRR, 2022).

Examples of cascading and compound impacts include the interconnectedness of infrastructure, energy, food, water systems and global trade, which increases vulnerability to compound impacts from climate events. For instance, drought combined with heat and low humidity can trigger wildfires and worsen food crises, affecting farmers and the economy. Heavy precipitation

can cause soil erosion, floods, and landslides, leading to significant damage and insurance claims (WMO, 2024b). Such events highlight the exposure of various sectors to climate risks, which can lead to increased insurance costs and economic instability. In January 2017, South Africa was hit with strong winds that, associated with dry conditions, led to record-breaking insured losses of US\$ 0.2 billion due to wildfires (Swiss Re, 2018). Events like this can cause losses to insurers due to substantial claims of catastrophe damage (from property owners, businesses and industries) and highlight the exposure of their portfolio to climate events. Consequently, rising premiums and reinsurance costs can lead insurers to pull back from areas of very high flood risk and, in more extreme cases, face solvency issues (*The Business Times*, 2024; *Financial Times*, 2024). Over time, there is also a risk that certain climate risks might become uninsurable, particularly in areas highly exposed to the impacts of climate change. This can make households, businesses, communities, and infrastructure even more vulnerable. Being able to evaluate climate risks and eventual losses is key to ensuring the long-term viability of risk-sharing mechanisms between public and private sectors and the overall financial sustainability of investments.

How to measure future climate conditions?

Measuring past and future climate conditions provides the base of evidence for understanding hazards such as floods, droughts, storms, or heatwaves. To support accurate climate risk modelling, scientists use a combination of direct and indirect measurement methods to gather both historical and projected climate information:

- **Direct Measurements:** Scientists rely on real-time data from satellite observations, weather stations and ocean buoys. These tools capture essential climate variables such as temperature, precipitation, and atmospheric pressure, forming the backbone of short- and long-term climate monitoring.

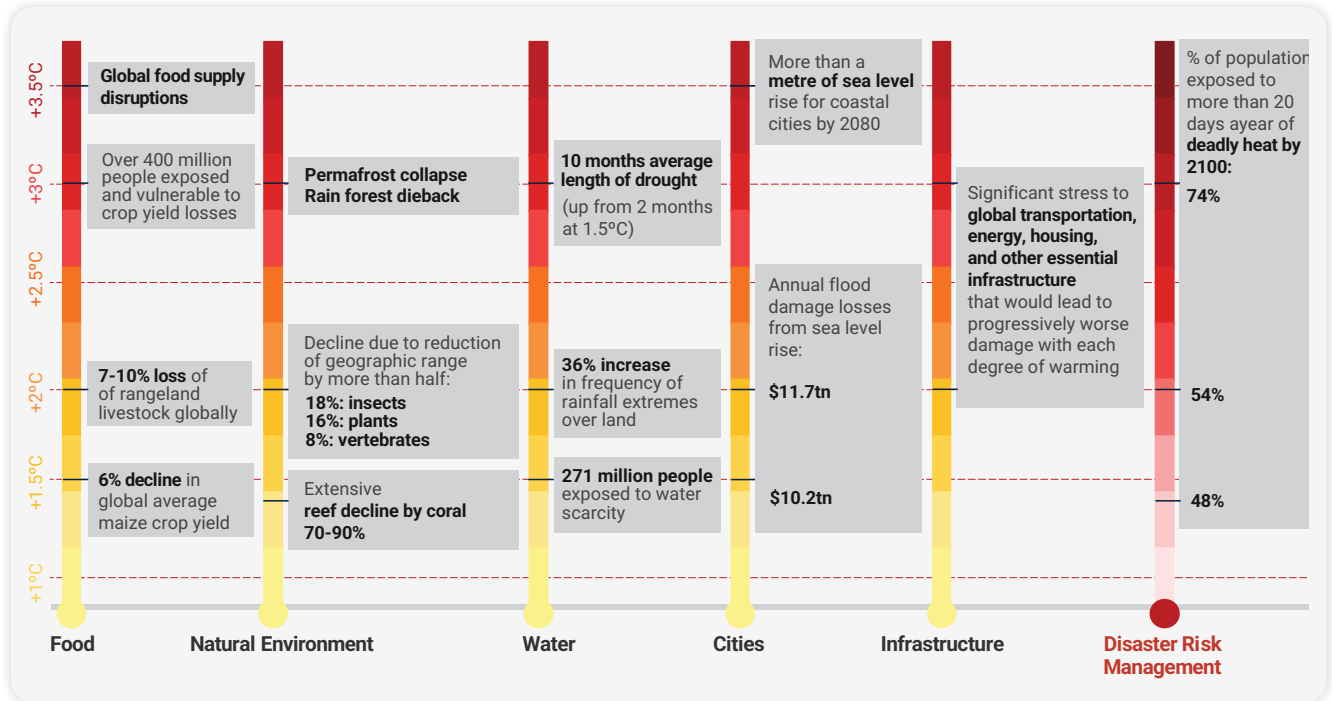
- **Indirect (Proxy) Measurements:** To understand past climate conditions, researchers analyse ice cores, tree rings, sediment layers and chemical signatures. These proxy indicators help reconstruct historical climate patterns and anomalies across centuries or even millennia.

Climate models simulate how the Earth’s systems may respond under different conditions (University Corporation for Atmospheric Research, 2024; National Aeronautics and Space Administration, 2024). These models help in understanding potential impacts on ecosystems, weather patterns, and human activities (Zehnder et al., 2018). This analysis,

which can be used by FIs, helps assess sector- and geography-specific vulnerabilities (see **Figure 7**) by combining backwards-looking data (e.g., past hazard

events, historical precipitation trends) and forward-looking climate projections.

Figure 7: How climate scenarios can lead to different climate risks across sectors



Source: Global Commission on Adaptation (2019).

It is important to recognise that historical data and future climate projections have different purposes. While historical data helps FIs understand baseline hazard patterns and past disruptions, future climate scenarios and projections enable them to assess how risks may

evolve over the lifetime of loans and investments. Using these insights together can, therefore, support FIs to assess potential impacts on clients, portfolios, and sectors, as well as design adaptation finance strategies that directly reduce exposure and vulnerability.

What are climate scenarios, and how do they differ from climate models and climate projections?

Climate scenarios are hypothetical projections of future climate conditions based on various assumptions about key driving forces such as greenhouse gas emissions, socioeconomic factors, and technological developments. They are used to explore possible futures and to help policymakers, companies or FIs (see Module 3) to understand the broad impacts of different actions on extreme weather events, biodiversity loss, and global economic shifts.

Climate models are computational models built to simulate the Earth's climate system. They use

the assumptions adopted by climate scenarios to understand how the climate system might change in the future under different conditions. Finally, climate projections are the outcomes derived from climate models that simulate future climate conditions based on the input climate scenarios. They provide detailed estimates of climate variables in the future, such as temperature and precipitation, under each of the scenarios used.

Climate scenarios, models, and projections can be analysed at different levels, including global,

regional, and area or sector-specific levels. As illustrated in **Table 6**, this scalability allows for a broad understanding of global trends, while also enabling more precise, actionable strategies at

local or sectoral levels where specific impacts and vulnerabilities may vary significantly. They are often a key component of climate risk modelling for FIs, as discussed in Module 3.

Table 6: Examples of levels of analysis for climate models, scenarios and projections

Level	Focus	Key Features	Purpose
Global	GHG, global temperature, and sea level rise	<ul style="list-style-type: none"> Broad climate trends Global models Planet-wide impacts (e.g., biodiversity loss, economic shifts) 	Understand the overarching impacts of climate change for global policy and coordination; competency in FI climate risk modelling
Regional	Local climate conditions and vulnerabilities	<ul style="list-style-type: none"> Region-specific projections Integration with in-situ data from measurement stations Alignment with local context 	Support tailored responses to local climate risks and build regional resilience
Area or Sector-specific	Impact on specific industries (e.g., agriculture, energy, transport)	<ul style="list-style-type: none"> Industry-relevant variables (e.g., crop yields, energy demand) Targeted adaptation strategies 	Help sectors prepare for and adapt to climate-related disruptions

Source: Authors.

What types of global climate scenarios exist?

Climate scenarios are used to explore different possible futures based on varying levels of GHG emissions and other factors. The basis for predicting future climatic conditions is the global climate scenarios published by IPCC, namely the representative concentration pathways (RCPs) or **shared socio-economic pathways (SSPs)**.

- **RCP** scenarios focus on different levels of GHG concentrations in the atmosphere, air pollution, and land use change. There are four scenarios to report GHG concentrations and their impact on the climate, ranging from low-emission scenarios (RCP2.6) to high-emission scenarios (RCP8.5).
- **SSP** scenarios consider various socio-economic factors like population growth (and literacy rate), urban growth, economic development (measured in GDP), and technological advancements,

illustrating whether (global) climate policies are likely to be achieved or not and, for example, how warmer the global temperatures will be. The most common climate scenarios used to represent the SSPs explore how different societal choices impact climate outcomes and range from SSP scenarios, from low-emission (SSP1-1.9) to high-emission (SSP5-8.5).

The main difference between RCPs and SSPs and each of the pathways they consider is the extent to which climate indicators will change. RCP scenarios focus on different levels of GHG concentrations, while SSPs set the socioeconomic context that influences emissions and mitigation. For understanding direct climate impacts (e.g., temperature rise and sea level changes), RCPs are crucial. In contrast, SSPs are essential for exploring broader societal influences on climate and planning policy responses. As they

capture how different socioeconomic pathways may affect climate vulnerability and adaptive capacity, SSPs are particularly important for adaptation planning. In addition, they represent the most current set of climate scenarios available.

Table 7 shows a comparison between RCPs and SSPs and what they represent in terms of projected sea level

rise and temperature. This understanding is important because, while for a mean increase of 0.38 m in sea level for SSP1-1.9, industries, and businesses in coastal areas might not be impacted by flooding events, the situation can be full damage for the 0.77 m increase in a more extreme condition (SSP5-8.5) and, therefore, considerably change the total volume of insurance claims to banks from flood damages.

Table 7: Comparison of projected mean surface temperature and sea level increase for representative concentration pathways and shared socioeconomic pathways

Indicator	Representative Concentration Pathways			Shared Socio-economic Pathways		
	Scenario	Mean	Likely Range	Scenario	Mean	Likely Range
Global mean surface temperature change (°C)	RCP2.6	1.0°C	0.3°C-1.7°C	SSP1-1.9	1.4°C	1.0°C-1.8°C
	RCP4.5	1.8°C	1.1°C-2.6°C	SSP1-2.6	1.8°C	1.3°C-1.4°C
	RCP6.0	2.2°C	1.4°C-3.1°C	SSP2-4.5	2.7°C	2.1°C-3.5°C
	RCP8.5	3.7°C	2.6°C-4.8°C	SSP3-7.0	3.6°C	2.8°C-4.6°C
				SSP5-8.5	4.4°C	3.3°C-5.7°C
Global mean sea level rise (m)	RCP2.6	0.40m	0.26m-0.55m	SSP1-1.9	0.38m	0.28m-0.55m
	RCP4.5	0.47m	0.32m-0.63m	SSP1-2.6	0.44m	0.32m-0.62m
	RCP6.0	0.48m	0.33m-0.63m	SSP2-4.5	0.56m	0.44m-0.76m
	RCP8.5	0.63m	0.45m-0.82m	SSP3-7.0	0.68m	0.55m-0.90m
				SSP5-8.5	0.77m	0.63m-1.01m

Source: Authors, adapted from IPCC (2014, 2021).



What are the limitations of climate scenarios?

Climate scenarios are essential tools for assessing the potential impacts of climate change; however, they face key limitations in terms of resolution, uncertainty, and data quality (see **Table 8**). Uncertainty arises from the complexity of the climate system, the variability of natural processes, the unclear reliability of climate projections, and the quantification of climate risks.

This is reflected in the range of possible outcomes across different climate scenarios (see RCPs or SSPs in **Table 7**) and must be factored into decision-making because it can influence the financial and economic viability of investments. The lack of understanding of cascading impacts adds another layer of complexity to understanding the impacts of climate risks.

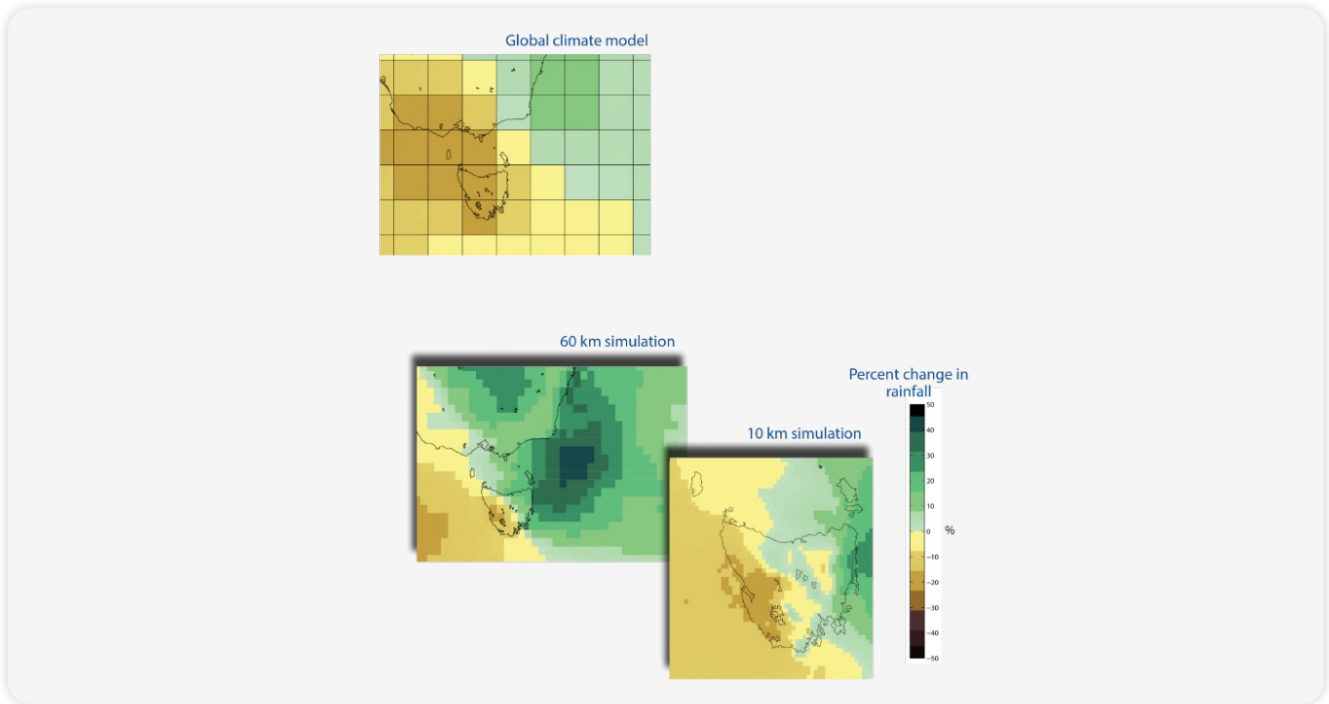
Table 8: Limitations of climate scenarios

Aspect	Description	Implications
Uncertainty	Climate models inherently involve uncertainty due to complex systems and natural variability. This affects the reliability of projections.	Decision-makers must account for uncertainty in scenario planning, as it impacts investment viability and risk assessments.
Resolution	Climate models typically have coarse spatial resolution, which may not capture fine-scale local variations. Downscaling methods improve resolution but introduce added uncertainty.	High resolution is crucial for project-level analysis to understand localised risks; less critical at the portfolio level, where broader trends are assessed.
Data Quality	The effectiveness of projections depends on the quality and completeness of historical climate data. Gaps or inaccuracies can compromise model outputs.	Access to reliable, locally sourced data, e.g., from hydrometeorological stations and climate agencies, is essential to support robust climate analysis and inform localised adaptation or investment strategies.

Source: Authors.

Global climate projections are relatively coarse, with a resolution of about 100km, meaning they tend to indicate the same climate trends for a large area. To capture local differences more accurately, downscaled climate projections are used. This low resolution limits their usefulness for understanding local-level climate impacts. Downscaling addresses the resolution limitation by refining global climate model outputs

to provide more detailed, local-scale projections. To capture regional and local climate variations more accurately, downscaling methods are used to improve the resolution of projections, typically to about 28km, and in some cases even to 5km resolution, when robust and extensive data from meteorological stations is available. **Figure 8** shows how increasing data resolutions enhances the information granularity.

Figure 8: Example of different resolutions of climate data

Source: *Climate Futures (n.d.)*

For FIs, downscaled climate scenarios are crucial in enabling effective risk management. As discussed in Module 3, they rely on these localised projections to assess both physical and transition risks, guide investment decisions, ensure regulatory compliance, and advise clients on risk mitigation and sustainable financing. For example, an FI with significant investments in agriculture can use downscaled data

to evaluate the risk of changing precipitation patterns and temperature extremes on crop yields. This allows the bank to adapt its portfolio, offer targeted financing for climate adaptation, and provide strategic advice to clients to protect their agricultural assets. Nevertheless, despite improvements in resolution, challenges remain due to persistent uncertainties and data quality issues.



How does data quality impact climate model outputs, and how can it be improved?

Climate models heavily rely on the availability of in situ or local data from meteorological stations. In many countries, the lack of coverage of stations, the temporal scale of measurements, and the lack of reliability are often limiting factors in the availability of climate data. Data quality affects how well the climate models can represent the local or regional climate conditions. If data is not available, global and regional climate models can still give a relevant representation of the projected climate impacts. However, to deal with this lack of data, field surveys, key informant

interviews, site inspections, and other techniques for primary data collection can be applied to compile local data that can help provide a better understanding of the local context (see **Table 9**). That information can subsequently be used to validate climate models and projections. Other techniques, such as interactive stakeholder workshops and participatory mapping, could also facilitate the collection and interpretation of climate data by involving local stakeholders. The table below shows data quality impacts the model output.

Table 9: Impact of data quality on the model output

Aspect	Description
Reducing Accuracy	Incomplete or inaccurate historical data can lead to less precise projections.
Increasing Uncertainty	Gaps in data contribute to higher levels of uncertainty in model predictions.
Bias in Results	Missing data can introduce biases, affecting the reliability of the model's outputs.
Limited Validation	Without comprehensive data, it is harder to validate and calibrate models against real-world conditions.

Source: Authors.

The analysis of climate indicators and models, therefore, requires a process of bias correction (e.g., statistical analysis to adjust projections to a baseline period) and validation (e.g., verification with past hazard events or local expert knowledge) to ensure they are aligned with the context of the analysis. Two ways of reducing uncertainty and improving data quality are:

- using data from meteorological stations (from past events) for calibration of climate models, validation of outputs, and overall to ensure that the baseline climate conditions between the model and the measured data are aligned; and
- inputs from local stakeholders to facilitate interpretation of the information provided through analysis of climate indicators and the impact they have on the economy, infrastructure, people, and nature.

As discussed in Module 3, for FIs, understanding these limitations is essential because climate scenarios are a highly valuable tool for assessing physical and transition risks, informing investment strategies, complying with regulatory expectations, and supporting clients in climate adaptation. Improving the accuracy of data and contextual relevance of data further enhances the insights scenarios can provide on portfolio exposure and the climate risks threshold they should consider in investment decisions.


04

Climate Risk Transmission Channels in the Financial Sector

With a stronger understanding of climate science and risk, FIs can now begin to evaluate how those risks are transmitted to their own portfolios and operations. By understanding how climate risks translate into financial risks, FIs can protect their portfolios and position themselves as leaders in financing resilience, unlocking investment opportunities in a changing climate. This chapter outlines how climate risks are transmitted through clients and sectors, what makes these risks distinct from conventional financial risks, and how targeted adaptation investments can improve credit quality, open new revenue streams and support regulatory alignment.

This chapter addresses the following questions:

- **How does climate change impact FIs?**
- **What are the distinct features of climate-related risk drivers for FIs?**
- **How are climate impacts on the clients transmitted to FIs?**
- **How are climate risks reflected in credit, market, operational, and liquidity risk profiles?**
- **How does a client's ability or failure to adapt affect creditworthiness and access to finance?**
- **How can FIs respond to the impacts of climate risks?**

 **Target Group:** Executive Management; Strategy Department; Sustainability/ESG, Risk Management (incl. Credit Risk, Operational Risk, Market Risk) and Compliance Departments; Corporate/ Wholesale, SME, and Retail Banking Departments; Credit, Product and Structured Finance Departments; Corporate Communications and External Affairs Department.

Climate Change Impacts on Financial Institutions

How does climate change impact FIs?

Exposure to climate risks for FIs occurs in two primary ways: direct involvement and through their counterparties.

- Direct climate risk exposure refers to the impact of climate-related events on an FI's own assets, operations or infrastructure, for example, physical damage to branch offices or data centres caused by storms or floods.
- Indirect exposure arises from the vulnerabilities of the FI's clients, or counterparties, such as households, businesses, or governments. These

entities may suffer financial losses or declines in asset values due to climate impacts or face increased costs or business disruption resulting from transition policies, such as new carbon regulations or technology shifts.

Climate risk drivers encompass climate-related changes that can lead to financial risks, categorised into physical and transition-related climate risks (see **Box 2**). As discussed in the previous chapter, **acute** and **chronic physical risks** arise from weather and climate changes impacting economies.

Box 2: Transition-related climate risk

Transition-related climate risk refers to the risks related to extensive policy, technology, and market changes that occur to meet the requirements for accelerating the transition towards a low-carbon economy (TCFD, 2017; NGFS, 2019).

Transition risk is more closely linked to mitigation action because it is related to the proactive measures to reduce GHG emissions and prevent further climate change (see **Box 3**). As regulations on the carbon intensity of energy are implemented, assets can

become stranded, unable to operate profitably or meet new environmental standards. In contrast, adaptation focuses on adjusting to the physical impacts of climate change that are already occurring (see Module 1).

Box 3: Transition risk implications for businesses

Example: The European Union carbon border adjustment mechanism

A mid-sized food processing company using outdated, high-emission equipment faces significant transition risk under the EU Carbon Border Adjustment Mechanism. If the company exports to the EU, its products could face higher tariffs due to their carbon intensity, making them less competitive. The cost of upgrading to cleaner technologies is high, and without access to green financing, the company may struggle to afford the necessary changes. As a result, it risks losing key export markets, facing penalties, and potentially damaging its financial stability. The transition to more sustainable practices is essential to remain competitive, but the upfront costs pose a significant challenge.

Example: Adapting to global demand for sustainable and eco-friendly products

A small agricultural business in Asia that relies on traditional farming methods may face transition risk as global demand shifts towards sustainable and eco-friendly products. If the business exports to markets with strict environmental regulations, like the EU, it may struggle to meet sustainability standards. The cost of switching to greener farming practices, such as adopting organic methods or reducing emissions, could be too high without access to concessional financing. As a result, the business risks losing access to key export markets or facing higher costs to comply with regulations, potentially impacting its profitability and growth.

Source: Authors.

However, transition-related climate risks and physical risks are closely interconnected. Physical risks can trigger or amplify transition risks. For example, severe weather events may prompt stricter climate policies, accelerating the transition to a low-carbon economy (McKinsey Global Institute, 2020). At the same time, a rapid and early shift to a carbon-neutral economy can help mitigate climate change and reduce long-term physical risks. However, this may increase short-term

transition risks, such as policy uncertainty or stranded assets. Conversely, delaying climate policies and decarbonization results in higher emissions, raising the likelihood of more frequent and more severe physical climate shocks (Battiston et al., 2020). In this way, inaction on transition can heighten physical risks, while strong physical risk events can drive more abrupt transition responses.

What are the distinct features of climate-related risk drivers for FIs?

Climate-related risk drivers for FIs have distinct structural features that differentiate them from traditional financial risks. Climate change risks:

- have far-reaching impacts across multiple economic agents, sectors and geographies
- are surrounded by significant uncertainty in terms of timing, scale and effects
- can lead to irreversible consequences
- are shaped by a mix of short-, medium-, and long-term developments.

These characteristics (summarised in **Table 10**) make it difficult to assess and manage the links between climate change, the financial sector, and the real economy. As a result, implementing effective risk management and mitigation strategies for FIs becomes more complex.

Table 10: Distinct features of climate-related risks for financial institutions

Feature	Description
Far-reaching impact	<ul style="list-style-type: none"> Financial risks from physical and transition risks are relevant to multiple economic agents, sectors and geographies Potential to generate cascading risk, amplifying their impact across the economies and financial system The proportion of physical and transition risks is uncertain, but financial risks will arise from a combination of both types of risks
Uncertainty	<ul style="list-style-type: none"> The exact timing, location, frequency and magnitude of financial risk from physical climate impacts are uncertain and subject to non-linearities (e.g., unpredictable and disproportionate responses of the climate system to changes or events) Uncertainty about future climate scenarios is shaped by changes in policies, technological innovation and shifts in consumer sentiment Using past data may not be sufficient to estimate future risks
Irreversible Impact	<ul style="list-style-type: none"> Climate change has long-lasting and often irreversible effects Challenge in quantifying the financial impact of permanent financial losses due to asset devaluation and stranded assets Potential impact on long-term shifts in market dynamics and investment priorities
Combination of short-, medium- and long-term measures	<ul style="list-style-type: none"> Impact may appear outside the current business planning or financing horizon (tragedy of the horizon) Magnitude of impact will partly depend on actions by governments, financial market participants, and other actors today (cost of inaction)

Source: Compiled from Battiston et al. (2020), Financial Stability Board (2025), and NGFS (2019, 2020c).

Also, from a financial stability perspective, climate-related financial risk is significant due to potential losses that financial intermediaries may incur from exposures to physical or transition risks. This can create a snowball or cascading effect (see

Box 4), where increased defaults diminish lending capacity and further strain financial stability. Clients in climate-vulnerable sectors may face higher default risks, impacting the stability of loan portfolios held by banks and other FIs.

Box 4: Example: The cascading effect from climate shock to economic slowdown

A prolonged drought in an agriculture-dependent region can trigger a cascading chain of economic impacts. As crops fail on a large scale, farmers and agribusinesses face significant income losses, leading many to default on their loans. FIs with high exposure to the agricultural sector may then experience increased credit losses, prompting them to tighten lending criteria or reduce loan disbursements altogether. This contraction in credit availability slows down local economic activity, affecting agriculture and related sectors such as retail, transportation, and agri-processing. In this way, a climate hazard initially concentrated in one sector can ripple through the broader economy, amplifying financial risks and undermining stability.

Source: Authors.

Transmission Channels of Climate Risks to Financial Institutions

How are climate impacts on the clients transmitted to FIs?

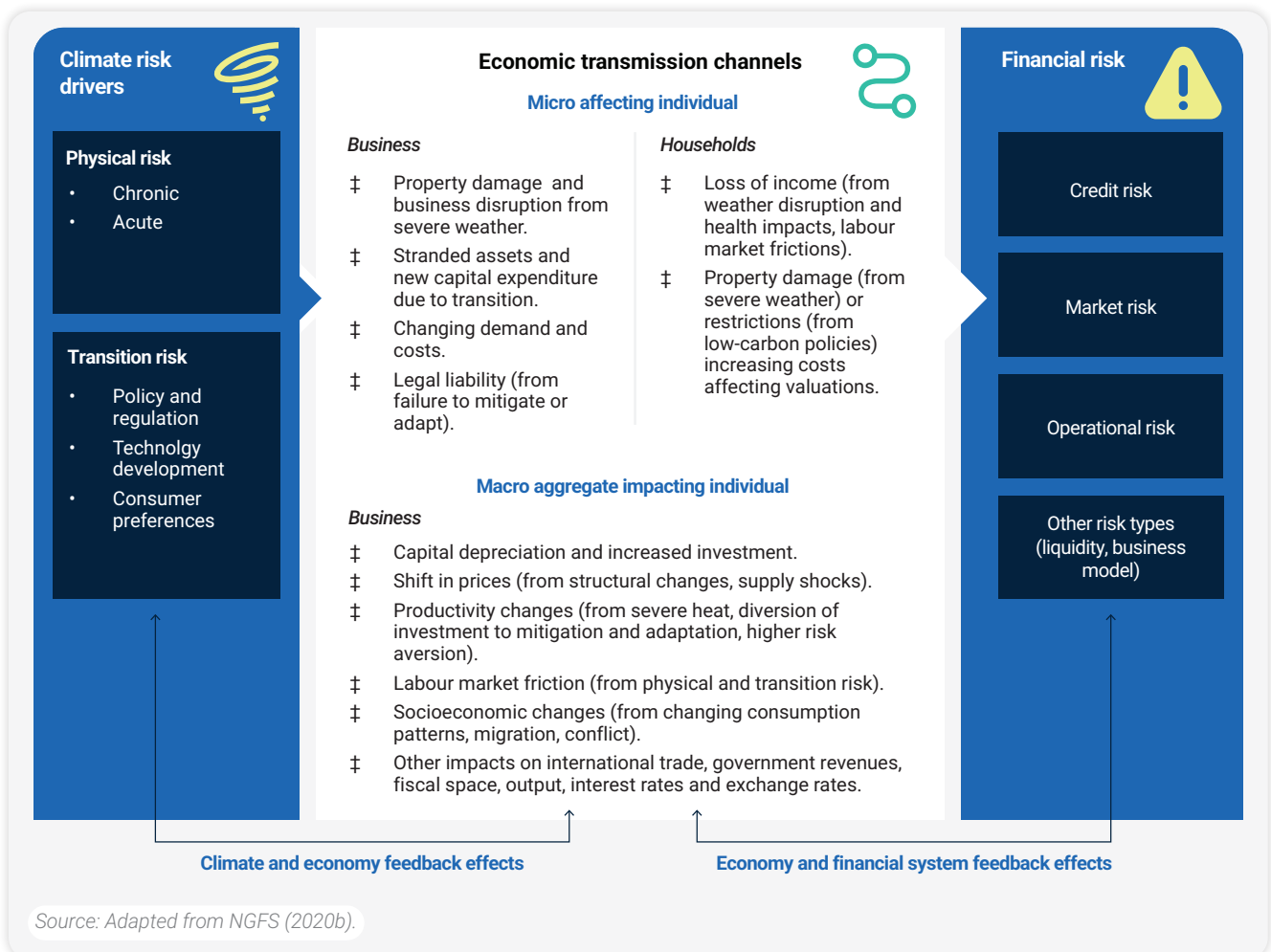
Transmission channels illustrate how climate change can materialise as a systemic financial risk (NGFS, 2020c; European Central Bank [ECB], 2020; Bank for International Settlements, 2021) that affects not just individual institutions, but the stability and functioning of the entire financial system (see **Figure 9**). These channels are typically categorised into:

- Microeconomic channels describe how climate risks impact the creditworthiness, operations, and asset values of counterparties and FIs.
- Macroeconomic channels explain how climate risks influence broader economic variables, such

as GDP growth, labour productivity, inflation, interest rates, and commodity prices, which in turn affect the financial system through shifts in market conditions, asset prices, and funding costs.

Together, these transmission mechanisms help explain how climate risk drivers contribute to traditional financial risk categories, including credit, market, liquidity and operational risks. Understanding these pathways is essential for FIs and regulators seeking to assess climate-related vulnerabilities within FIs and across the financial system .

Figure 9: Transmission channels from climate risk drivers



Clients are significantly impacted by both physical and transition climate risks, and these impacts can be transmitted to FIs through several channels. For example, when clients face losses from extreme weather events, supply chain disruptions, or policy-driven cost increases (e.g., carbon pricing), they may experience reduced revenues, asset devaluation,

or increased default risk. These effects can then materialise for FIs as credit losses, market value changes, or operational disruptions. The prominence of each risk varies based on factors such as sector and client type. **Table 11** provides some examples, with more in Module 4.

Table 11: Sector- and client-specific vulnerabilities

Sector-Specific Vulnerabilities	Client-Specific Vulnerabilities
Agriculture: Risks from extreme weather events, changing precipitation patterns, and temperature shifts , e.g., crop failures due to droughts, reduced livestock health, and food insecurity.	Individuals and Households: Personal assets, health, and livelihoods affected by climate risks , e.g., homes damaged by floods, health impacts from heatwaves, loss of income from climate-affected jobs.
Real Estate: Property values are impacted by increased flooding, sea-level rise, and other climate-related events , e.g., coastal property damage from rising sea levels, and urban flooding affecting infrastructure.	Micro, Small, and Medium-sized Enterprises (MSMEs): Limited resources to adapt to climate risks, making them more vulnerable to disruptions , e.g., smallholder farmers losing crops to drought, small businesses affected by supply chain disruptions
Tourism: Destinations affected by extreme weather and changing climate conditions , e.g., reduced tourist arrivals due to coral bleaching, damage to natural attractions.	Large Corporations: Supply chain disruptions, regulatory changes, and reputational damage , e.g., mining companies facing water shortages, manufacturing plants affected by power outages.

Source: Authors.

How are climate risks reflected in credit, market, operational and liquidity risk profiles?

Both physical and transition risks are reflected in FIs' credit, market, operational, and liquidity risk profiles, often by increasing the magnitude or frequency of these risks

(see **Table 12**). For example, credit risk may rise due to borrower defaults caused by extreme weather events or the devaluation of carbon-intensive assets.

Table 12: Examples of climate risk drivers affecting financial risk categories

Financial Risk Categories	Physical Risk	Transition Risk
Credit risk	<ul style="list-style-type: none"> Increased flood risk impairs collateral values, affecting mortgage portfolios Declining agricultural outputs increase defaults, lower corporate profitability, and reduce household incomes 	<ul style="list-style-type: none"> Tightening energy efficiency standards impacts property exposure Stranded assets impair loan portfolios Disruptive technology leads to financial losses
Market risk	<ul style="list-style-type: none"> Severe weather events lead to re-pricing of sovereign debt (e.g., higher borrowing costs, reduced debt market access and deteriorating fiscal positions) 	<ul style="list-style-type: none"> Tightening climate-related policy leads to repricing of securities and derivatives
Operational risk	<ul style="list-style-type: none"> Disruption of FI's operations due to physical damage to its property, branches, telecommunication, and data centres because of extreme weather events Disruption of FI's operations due to climate hazards affecting staff 	<ul style="list-style-type: none"> Changing consumer sentiment regarding climate issues can lead to volatility in prices and demand Loss of customer trust
Other risk types (liquidity, business model)	<ul style="list-style-type: none"> Increasing compliance, liability and reputational risks due to their investments and lending activities in carbon-intensive sectors 	<ul style="list-style-type: none"> Pressure and campaigns from investors, non-governmental organizations and climate activists can increase these risks and may also increase bank credit risk or even precipitate a corporation's default Writing off assets (stranded assets)

Source: Adapted from ECB (2020), Bank for International Settlements (2021) and Bank of England (2018).

How does a client's ability or failure to adapt affect creditworthiness and access to finance?

In the context of adaptation finance, it is important for FIs to understand how clients' abilities or failures to adapt to physical climate risks affect their creditworthiness and access to finance (see **Figure 10**). Clients who proactively respond to climate risks by investing in resilience or adopting sustainable practices tend to demonstrate stronger financial stability, which positively impacts their credit profiles. These clients face a lower risk of income or operational disruption and often maintain more stable cash flows, improving their loan repayment capacity. In addition, their assets, such as climate-resilient infrastructure, are less likely to lose value, thereby strengthening their collateral quality. As a result, FIs are more likely to view these clients as lower risk,

making them eligible for favourable lending terms, green finance products, or public support schemes. A farmer who installs drip irrigation to manage drought risk is more likely to sustain yields and remain creditworthy, making them an attractive client for lenders.

In contrast, clients who fail to adapt are more vulnerable to climate shocks and the associated financial consequences. These clients face a higher likelihood of income loss, asset damage, or operational interruptions, increasing their risk of default. Their collateral may also be devalued, particularly if located in high-risk areas. As a result, FIs may perceive them as high-risk, leading to

higher interest rates, shorter loan tenures, or even denial of credit. They may also miss out on green or climate-linked financing opportunities. For instance, an SME that does not upgrade its equipment to meet

new emissions standards could lose contracts or incur penalties, weakening its financial position and damaging its credit.

Figure 10: Client effect on creditworthiness



Source: Authors, adapted from TCFD (2017).

How can FIs respond to the impacts of climate risks?

By adopting proactive adaptation measures into core decision-making (see Module 1), FIs can manage the impacts of climate risk while also creating long-term value. Systematic risk assessment and monitoring enable them to identify vulnerable clients, sectors, and

assets, strengthening portfolio resilience (Modules 2 and 3). Developing climate-resilient loans, insurance schemes, and technical advisory services helps clients reduce vulnerability while opening opportunities for innovative products (Modules 4 and 5). Embedding

climate considerations into lending and investment decisions enhances risk-adjusted returns and directs capital toward resilient projects. In addition, by engaging with clients to support risk management, adaptation and mitigation strategies, FIs can strengthen client relationships and promote resilience (Module 6). Finally, investing in their own resilience safeguards institutional operations, infrastructure and

systems, ensuring continuity and competitiveness in a changing climate and strategic engagement in climate adaptation finance.

The following example of a coastal city, **Box 5** illustrates how FIs' exposure to climate hazards can translate into both risks and opportunities for resilience.

Box 5: Example: Financial institutions' strategic responses to climate risk in a coastal city

Consider a coastal city prone to rising sea levels and increased frequency of severe storms due to climate change, where FIs have substantial investments in real estate and infrastructure projects.

Climate risk for FIs:

- **Hazard:** The increased likelihood of severe storms (acute) and rising sea levels (chronic) poses a direct threat to the physical assets and economic activities in the area.
- **Vulnerability:** Many of these properties are not adequately protected against flooding, and the local economy heavily depends on tourism, which can be disrupted by extreme weather events. Consequences include costly repairs and decreased property values, reduced number of visitors, and less revenue for local businesses.
- **Exposure:** FIs have large loan portfolios tied to properties and businesses in this coastal area, making them financially exposed to climate-related events. These assets may be built in areas prone to flooding.

Impact on FIs:

- **Loan Defaults:** Increased risk of property damage and business interruptions can lead to higher loan default rates.
- **Asset Devaluation:** Properties in high-risk areas may lose value, affecting the banks' collateral and overall asset quality (Clayton et al., 2021).
 - **Cash Flow:** Leasing fundamentals (rent, rental growth and vacancy) net of operating expenses and capital expenditures.
 - **Capitalisation Rate:** Capital market conditions, including the required return and risk premium, which reflect cash flow prospects and liquidity.
 - **Financing:** The cost and availability of funds from equity partners and mortgage debt, influenced by return requirements and property liquidity.
- **Increased Insurance Costs:** Higher insurance premiums for properties in vulnerable areas can affect clients' ability to repay loans, further increasing default risks.
- **Operational Disruptions:** Severe weather events can disrupt bank operations and services, impacting customer trust and business continuity.

FI response options: To address these risks, FIs can, for example,

- Integrate physical climate risk assessments into credit evaluation and portfolio management.
- Support clients with adaptation financing, such as loans for flood defences, resilient construction, and business continuity planning.
- Prioritise lending and investment in climate-resilient projects to reduce systemic exposure.
- Adjust risk-based pricing, incorporating climate resilience into loan terms and interest rates.
- Strengthen internal resilience by ensuring operational continuity, data recovery, and emergency preparedness in the face of climate disruptions.

Source: Adapted from Clayton et al. (2021).

05

Additional Resources



Further sources on climate change



Reports

- [IPCC's Sixth Assessment Report on Impacts, Adaptation and Vulnerability](#) provides an extensive overview of the key climatic changes observed worldwide that can support decision-making. A series of fact sheets with key findings is also available to facilitate the understanding of findings across its chapters. More details on the climate science behind the IPCC Sixth Assessment report and what each of the SSP pathways means can be found in the [full version of the report](#). The online [glossary](#) provides an overview of key terminologies and concepts.
- [Climate 101](#): An interactive dictionary about climate change unpacks key terms used in climate change negotiations, policies, and media in a simple way and in various languages.
- The [Post-Disaster Needs Assessments](#) conducted under the leadership of affected country governments are the most important tasks of the Standby Recovery Financing Facility. [The generated reports of the respective governments](#) are used to base the recovery and reconstruction plans and programs upon. They are also as the base document for discussions to determine international development assistance in cases requiring external assistance.



Data

- IMF's [Climate Change Dashboard](#) provides an extensive database of indicators related to GHG emissions, mitigation, adaptation, and the climate scenarios from the NGFS.
- <https://www.desinventar.net/> includes an [open-access database](#) which contains an inventory of hazard and disaster events worldwide since 1988.
- The European Commission's Copernicus Climate Change Service provides a collection of [datasets](#) of past, current and future climate indicators for Europe and across the world.
- OECD's [Laboratory for Geospatial Analysis](#) integrates geospatial information, statistical data and spatial modelling to develop and disseminate policy-relevant analyses. This includes a web-based portal with data on demography, climate, environment, transport and economy, among others, for municipalities and local areas across 41 countries.
- The European Commission's Joint Research Center (JRC) has developed the Geospatial Risk and Resilience Assessment Platform ([Resilience Toolbox - Resilience Rising](#)) to facilitate the analysis of geospatial data on critical infrastructures, including modules to assess network or cascading impacts, downtime or disruption in networks, and to quantify economic losses.



Publicly available tools and training

- The [Climate Change: From Learning to Action](#) course aims to upscale global climate literacy by providing a general understanding of climate change to a large number of potential change agents. It's a self-paced course of 8 hours in different languages: English, Spanish, French, Russian, Chinese.
- UNDRR has developed [technical guidance](#) on how to conduct comprehensive climate risk assessments in the context of climate change. This report outlines the steps and considerations in this process, and provides a list of datasets and resources across sectors.

06

Glossary



Unless otherwise specified, all the definitions are drawn from the IPCC (2023) Glossary.

Acute physical risks refer to those that are event-driven, including increased severity of extreme weather events, such as cyclones, hurricanes, or floods (TCFD, 2017).

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects.

Carbon dioxide (CO₂): A naturally occurring gas, CO₂ is also a by-product of burning fossil fuels (such as oil, gas and coal), of burning biomass, of land-use changes (LUCs) and of industrial processes (e.g., cement production). It is the principal

anthropogenic greenhouse gas (GHG) that affects the Earth's radiative balance. It is the reference gas against which other GHGs are measured and therefore has a global warming potential (GWP) of 1.

Chronic physical risks refer to longer-term shifts in climate patterns (e.g., sustained higher temperatures) that may cause sea level rise or chronic heat waves (TCFD, 2017).

Climate change: A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in

the composition of the atmosphere or in land use. Note that the United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes.

Climate model: A qualitative or quantitative representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes and accounting for some of its known properties. The climate system can be represented by models of varying complexity; that is, for any one component or combination of components a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical or biological processes are explicitly represented, or the level at which empirical parametrisations are involved. There is an evolution towards more complex models with interactive chemistry and biology. Climate models are applied as a research tool to study and simulate the climate and for operational purposes, including monthly, seasonal and interannual climate predictions.

Climate projection: Simulated response of the climate system to a scenario of future emissions or concentrations of greenhouse gases (GHGs) and aerosols and changes in land use, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which is in turn based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realised.

Climate system: The global system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the lithosphere and the biosphere and the interactions between them. The climate system changes in time under the influence of its own internal dynamics and because of external forcings such as volcanic eruptions, solar variations, orbital forcing,

and anthropogenic forcings such as the changing composition of the atmosphere and land-use change.

CO₂ equivalent (CO₂-eq) emission: The amount of carbon dioxide (CO₂) emission that would have an equivalent effect on a specified key measure of climate change, over a specified time horizon, as an emitted amount of another greenhouse gas (GHG) or a mixture of other GHGs. For a mix of GHGs it is obtained by summing the CO₂-equivalent emissions of each gas. There are various ways and time horizons to compute such equivalent emissions (see greenhouse gas emission metric). CO₂-equivalent emissions are commonly used to compare emissions of different GHGs, but should not be taken to imply that these emissions have an equivalent effect across all key measures of climate change.

Emissions: Direct emissions physically arise from activities within well-defined boundaries of, for instance, a region, an economic sector, a company, or a process. Indirect emissions are a consequence of the activities within well-defined boundaries of, for instance, a region, an economic sector, a company or process, but which occur outside the specified boundaries. For example, emissions are described as indirect if they relate to the use of heat but physically arise outside the boundaries of the heat user, or to electricity production but physically arise outside of the boundaries of the power supply sector.

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.

Greenhouse gases (GHGs): Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of radiation emitted by the Earth's surface, by the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H₂O), carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄) and ozone (O₃) are the primary GHGs in the Earth's atmosphere. Human-made GHGs include sulphur hexafluoride (SF₆), hydrofluorocarbons (HFCs), chlorofluorocarbons (CFCs) and perfluorocarbons (PFCs); several of these are also O₃-depleting (and are regulated under the Montreal Protocol).

Gross domestic product (GDP): The sum of gross value added, at purchasers' prices, by all resident and non-resident producers in the economy, plus any taxes and minus any subsidies not included in the value of the products in a country or a geographic region for a given period, normally one year. GDP is calculated without deducting for depreciation of fabricated assets or depletion and degradation of natural resources.

Hazard: The potential occurrence of a natural or human-induced physical event or trend 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.

Impacts: The consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather/climate events), exposure, and vulnerability. Impacts generally refer to effects on lives, livelihoods, health and well-being, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure. Impacts may be referred to as consequences or outcomes, and can be adverse or beneficial.

Maladaptation (maladaptive actions): Actions that may lead to increased risk of adverse climate-related outcomes, including via increased GHG emissions, increased or shifted vulnerability to climate change, more inequitable outcomes, or diminished welfare, now or in the future. Most often, maladaptation is an unintended consequence.

Methane (CH₄): The greenhouse gas methane is the major component of natural gas and associated with all hydrocarbon fuels. Significant anthropogenic emissions also occur as a result of animal husbandry and paddy rice production. Methane is also produced naturally where organic matter decays under anaerobic conditions, such as in wetlands. Under future global warming, there is potential for increased methane emissions from thawing permafrost, wetlands and sub-sea gas hydrates.

Mitigation (of climate change): A human intervention to reduce emissions or enhance the sinks of greenhouse gases.

Net zero GHG emissions: Condition in which metric-weighted anthropogenic greenhouse gas (GHG) emissions are balanced by metric-weighted anthropogenic GHG removals over a specified period. The quantification of net zero GHG emissions depends on the GHG emission metric chosen to compare emissions and removals of different gases, as well as the time horizon chosen for that metric.

Nitrous oxide (N₂O): The main anthropogenic source of N₂O, a greenhouse gas (GHG), is agriculture (soil and animal manure management), but important contributions also come from sewage treatment, fossil fuel combustion, and chemical industrial processes. N₂O is also produced naturally from a wide variety of biological sources in soil and water, particularly microbial action in wet tropical forests.

Physical risks resulting from climate change can be event driven (acute) or longer-term shifts (chronic) in climate patterns. Physical risks may have financial implications for organizations, such as direct damage to assets and indirect impacts from supply chain disruption. Organizations' financial performance may also be affected by changes in water availability, sourcing, and quality; food security; and extreme temperature changes impacting organizations' premises, operations, supply chain, transport needs, and employee safety (TCFD, 2017).

Representative concentration pathways (RCPs): Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover (Moss et al., 2008; van Vuuren et al., 2011). The word representative signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term pathway emphasises that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome (Moss et al., 2010; van Vuuren et al., 2011).

Resilience: The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation.

Scenario: A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change, prices) and relationships. Note that scenarios are neither predictions nor forecasts but are used to provide a view of the implications of developments and actions.

Shared socio-economic pathways (SSPs) have been developed to complement the representative concentration pathways (RCPs). By design, the RCP emission and concentration pathways were stripped of their association with a specific socio-economic development. Different levels of emissions and climate change along the dimension of the RCPs can hence be explored against the backdrop of different socio-economic development pathways (SSPs) on the other dimension in a matrix. This integrative SSP–RCP framework is now widely used in the climate impact and policy analysis literature, where climate projections obtained under the RCP scenarios are analysed against the backdrop of various SSPs. As several emissions updates were due, a new set of emissions scenarios was developed in conjunction with the SSPs. Hence, the abbreviation SSP is now used for two things: First, SSP1, SSP2,

..., SSP5 are used to denote the five socioeconomic scenario families. Second, the abbreviations SSP1-1.9, SSP1-2.6, ..., SSP5-8.5 are used to denote the newly developed emissions scenarios that are the result of an SSP implementation within an integrated assessment model. Those SSP scenarios are without climate policy assumptions, but in combination with so-called shared policy assumptions, various approximate radiative forcing levels of 1.9, 2.6, ..., or 8.5 W m⁻² can be reached by the end of the century, respectively.

Transition risks are related to extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements for accelerating the transition towards a lower-carbon economy. Depending on the nature, speed, and focus of these changes, transition risks may pose varying levels of financial and reputational risk to organizations (TCFD, 2017).

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

07

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08

Practice Questions

The following set of 15 single-response, multiple-choice questions is designed to test understanding of key concepts covered in **Module 2: Understanding Climate Change Science**. The questions are intentionally challenging and go beyond simple recall, requiring application, analysis, and comparison of concepts. The questions cover the following chapters of Module 2:

- **Chapter 1: Introduction to Climate Science for FIs**
- **Chapter 2: From Hazard to Vulnerability and Exposure**
- **Chapter 3: Sectoral and Geographic Impacts of Climate Change**
- **Chapter 4: Climate Risk transmission channels in the Financial Sector**

Each question has **four answer options**, with only **one correct solution**, followed by an explanation clarifying the reasoning and key learning points.

1 Why is it essential for FIs, particularly in climate-vulnerable regions, to build internal knowledge of climate science?

- A. To comply with environmental reporting requirements only.
- B. To quantify climate-related risks, align strategic planning with scientific data, and develop resilient financial solutions that meet regulatory and market expectations.
- C. To outsource climate risk assessments more efficiently.
- D. To shift all investments away from climate-sensitive sectors.

2 Which of the following statements best explains the difference between natural climate variability and atmospheric changes caused by human activities?

- A. Natural climate variability and human-induced atmospheric changes are identical in origin and impact.
- B. Natural climate variability refers to short-term fluctuations in climate patterns, while human-induced atmospheric changes result from GHG emissions and can intensify long-term climate impacts.
- C. Atmospheric changes caused by human activities are unpredictable and unrelated to natural climate cycles.
- D. Natural climate variability is responsible for all recent increases in global temperatures.

3 Why is understanding the causes of climate change critical for FIs when developing climate adaptation strategies?

- A. It allows FIs to predict short-term weather conditions and adjust daily operations accordingly.
- B. It enables FIs to avoid investing in any climate-sensitive sectors altogether.
- C. It helps FIs anticipate long-term shifts in climate patterns, align with climate scenarios, and design resilient financial solutions that complement mitigation efforts.
- D. It ensures that FIs can rely solely on mitigation strategies to address all climate-related risks.

4 Why is it important for FIs to understand the sources and impacts of GHGs when developing climate adaptation strategies?

- A. Because understanding GHGs helps FIs assess investment vulnerability, prioritise projects that reduce emissions, and design adaptation solutions aligned with regulatory and climate resilience goals.
- B. Because GHGs only affect mitigation efforts and are irrelevant to adaptation planning.
- C. Because GHGs have no measurable impact on asset values or portfolio risk.
- D. Because all GHGs have the same lifetime and warming potential, making a detailed analysis unnecessary.

5 Which of the following best describes the formula used to assess climate risk in FIs?

- A. Climate Risk = Emissions × Temperature × Regulation
- B. Climate Risk = Infrastructure × Investment × Insurance
- C. Climate Risk = Hazard × Exposure × Vulnerability
- D. Climate Risk = Weather × Geography × Policy

6 Which of the following scenarios illustrates a physical climate risk for an FI?

- A. A regulatory shift requiring banks to disclose carbon footprints.
- B. A cyclone damaging coastal infrastructure and disrupting supply chains.
- C. A sudden drop in asset value due to new carbon pricing policies.
- D. A change in consumer preferences toward low-emission products.

7 Which combination of factors most accurately determines the impact of a climate hazard on people, assets, and ecosystems?

- A. Temperature, humidity, and wind speed.
- B. Geographic location, population size, and economic activity.
- C. Government policy, media coverage, and public awareness.
- D. Intensity, frequency, and duration of the hazard event.

8 Which of the following best illustrates how different types of vulnerabilities, such as physical, social, financial, economic, environmental, and institutional, influence the impact of climate hazards on FIs? Vulnerabilities...

- A. ...only affect environmental systems and are not relevant to financial decision-making.
- B. ...are limited to physical infrastructure and do not include social or institutional factors.
- C. ...can always be eliminated through short-term financial interventions.
- D. ...determine how exposed assets and communities respond to climate hazards, guiding FIs in risk assessment and investment strategy.

9 An FI is evaluating the potential consequences of climate hazards on its regional portfolio. Which of the following scenarios best illustrates climate impacts?

- A. A flood damages agricultural land, disrupts supply chains, and reduces borrower repayment capacity in a vulnerable rural area.
- B. A heatwave occurs in a region with no population or infrastructure.
- C. A government announces new climate regulations for carbon reporting.
- D. A coastal city builds a seawall to prevent future storm surges.

10 Which of the following sets of impacts correctly illustrates how climate hazards affect economies, nature, and societies?

- A. Asset damage, ecosystem degradation, and displacement of communities.
- B. Economic losses, improved biodiversity, and increased urban employment.
- C. Infrastructure growth, stable ecosystems, and enhanced public health.
- D. Reduced investment risk, stronger ecosystems, and population growth.

11 An FI is assessing long-term climate risks under different global warming scenarios. Which of the following projections best illustrates the consequences of inaction on climate mitigation and adaptation?

- A. Global GDP loss limited to 4.2% by 2050, with minimal disruption to infrastructure and agriculture.
- B. A 27% drop in infrastructure investors' net asset value, 64% increase in global flood exposure, and significant crop losses in Africa under a high-emissions scenario.
- C. Full recovery of hydropower capacity and reduced hazard exposure due to natural climate variability.
- D. Stabilisation of port operations and agricultural productivity regardless of emissions trajectory.

12 How do climate scenarios support FIs in developing effective climate adaptation and risk management strategies?

- A. By predicting exact weather conditions for specific days and locations.
- B. By eliminating the need for climate risk modelling through standardised global temperature forecasts.
- C. By offering hypothetical projections of future climate conditions based on emissions, socioeconomic trends, and technology, enabling global, regional, and sector-specific planning.
- D. By focusing solely on mitigation strategies and excluding adaptation considerations.

13 Why are climate change impacts increasingly difficult to predict for FIs and other decision-makers?

- A. Because climate hazards can trigger cascading and compound impacts across interconnected systems, creating uncertainty and amplifying risks.
- B. Because climate hazards only affect isolated regions and have minimal economic consequences.
- C. Because climate impacts are linear and easily modelled using historical data.
- D. Because climate change is slowing down and becoming more stable over time.

14 How can climate-related impacts on clients translate into financial risks for FIs?

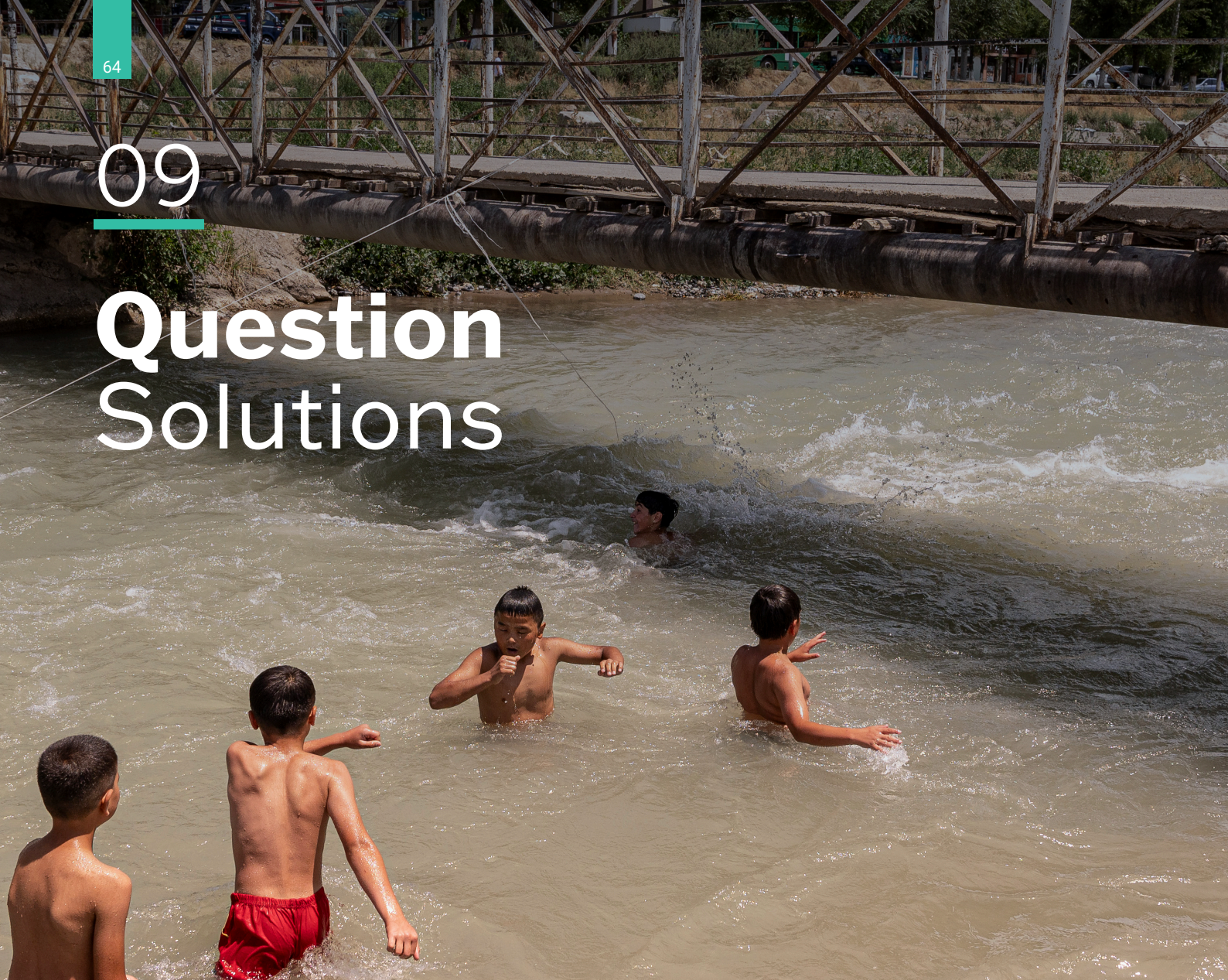
- A. Climate impacts on clients are isolated and do not affect FIs.
- B. Climate risks only affect large corporations and have no relevance for individual borrowers or MSMEs.
- C. Climate impacts are fully absorbed by insurance companies, shielding FIs from any financial consequences.
- D. When clients experience losses from climate hazards or policy changes, it can lead to reduced revenues, asset devaluation and increased default risk, which in turn affect FIs through credit losses, market disruptions and operational challenges.

15 Which of the following best describes why climate-related risk drivers pose unique challenges for FIs compared to traditional financial risks?

- A. Climate risks are far-reaching, uncertain in timing and scale, potentially irreversible, and unfold across short-, medium-, and long-term horizons, complicating risk assessment and financial stability.
- B. Climate risks are short-term and easily reversible, making them less relevant to long-term financial planning.
- C. Climate risks are limited to specific sectors and geographies, allowing for straightforward mitigation strategies.
- D. Climate risks are predictable using historical financial data and do not require specialised modelling or scenario analysis.

09

Question Solutions



1

Correct: B

Explanation: Building internal knowledge of climate science enables FIs to quantify climate-related risks, align strategic planning with scientific data, and develop resilient financial solutions that meet both regulatory and market expectations. This understanding is especially critical in climate-vulnerable regions, where informed decision-making can significantly reduce exposure and enhance long-term stability.

2

Correct: B

Explanation: Natural climate variability refers to short-term fluctuations in climate patterns caused by natural processes such as ocean currents, volcanic

activity, and solar cycles. In contrast, atmospheric changes caused by human activities result primarily from greenhouse gas emissions, which intensify long-term climate impacts like global warming and extreme weather events. Understanding this distinction is essential for accurately assessing and responding to climate risks.

3

Correct: C

Explanation: Understanding the causes of climate change is essential for FIs because it helps them anticipate long-term shifts in climate patterns, align their strategies with scientific climate scenarios, and design resilient financial solutions. This knowledge also supports the integration of adaptation efforts with mitigation strategies, enabling institutions to manage risks more effectively and contribute to sustainable development.

4

Correct: A

Explanation: Understanding the sources and impacts of greenhouse gases helps FIs assess the vulnerability of their investments, prioritise projects that contribute to emission reductions, and design adaptation strategies that align with both regulatory requirements and climate resilience goals. This knowledge supports informed decision-making and strengthens the institution's ability to manage long-term climate risks.

5

Correct: C

Explanation: The formula $\text{Climate Risk} = \text{Hazard} \times \text{Exposure} \times \text{Vulnerability}$ reflects how FIs assess climate risk. It considers the likelihood and severity of climate-related hazards (such as floods or droughts), the degree to which assets or operations are exposed to these hazards, and how vulnerable those assets are to damage or disruption. This comprehensive approach helps institutions understand and manage potential impacts on their portfolios and operations.

6

Correct: B

Explanation: A cyclone damaging coastal infrastructure and disrupting supply chains illustrates a physical climate risk for a FI. Physical risks stem from direct impacts of climate-related events, such as extreme weather, which can affect asset values, borrower repayment capacity, and overall financial stability.

7

Correct: D

Explanation: The impact of climate hazards on people, assets, and ecosystems is most accurately determined by their intensity, frequency, and duration. These factors influence how severe a hazard is, how often it occurs, and how long its effects last, all of which are critical in assessing potential damage and planning effective adaptation strategies.

8

Correct: D

Explanation: Vulnerabilities, such as physical, social, financial, economic, environmental and institutional, play a critical role in determining how exposed assets and communities respond to climate hazards. These factors influence the severity of impacts and guide FIs in assessing risk and shaping investment strategies that promote resilience and sustainability.

9

Correct: A

Explanation: A flood damaging agricultural land, disrupting supply chains, and reducing borrower repayment capacity in a vulnerable rural area illustrates a climate impact. It shows how climate hazards directly affect economic activities, asset values, and financial stability, making them a critical concern for FIs operating in climate-sensitive regions.

10

Correct: A

Explanation: Asset damage, ecosystem degradation and displacement of communities correctly illustrate how climate hazards affect economies, nature, and societies. These impacts disrupt livelihoods, reduce biodiversity, and strain social systems, making them critical considerations for FIs when assessing climate-related risks and planning adaptation strategies.

11

Correct: B

Explanation: A 27% drop in infrastructure investors' net asset value, a 64% increase in global flood exposure, and significant crop losses in Africa under a high-emissions scenario illustrate the severe consequences of inaction on climate mitigation and adaptation (OECD, 2024 and École des Hautes Études Commerciales du Nord, 2023). These projections highlight how failing to address climate risks can lead to widespread economic disruption, asset devaluation and food insecurity, especially in vulnerable regions.

12

Correct: C

Explanation: Climate scenarios help FIs by providing structured projections of possible future climate conditions based on varying emissions, socioeconomic developments and technological changes. These scenarios guide strategic planning by highlighting potential risks and opportunities across regions and sectors, enabling institutions to build resilient adaptation and risk management strategies.

13

Correct: A

Explanation: Climate change impacts are harder to predict because one hazard (like a flood, drought or heatwave) can set off chain reactions across connected systems such as supply chains, energy grids, agriculture, insurance losses and financial markets. These cascading and compound effects make outcomes more uncertain and can amplify risks for FIs and decision-makers.

14

Correct: D

Explanation: When clients are affected by climate-related hazards or policy shifts, they may suffer financial losses, reduced income or asset devaluation. This can increase their risk of defaulting on loans or failing to meet financial obligations. These impacts directly translate into financial risks for institutions through credit losses, market instability and operational disruptions, making climate risk a critical concern for financial decision-making.

15

Correct: A

Explanation: Climate-related risk drivers pose unique challenges because they are widespread, unfold over varying time horizons, and often involve deep uncertainty and potential irreversibility. Unlike traditional financial risks, they cannot be easily predicted or managed using historical data alone, requiring specialised approaches to assess the long-term impacts on financial stability and institutional resilience.



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