BANK & FINANCE

Climate Change and Financial Risks: Navigating the Transition and Managing Physical Exposure

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Executive Summary

Climate change is no longer a distant concern, it is a pressing and accelerating systemic risk to financial systems, human wellbeing, and global economic stability. Its impacts are already being felt through physical disruptions and the policy-driven transition to a low-carbon economy. These dynamics pose distinct but interrelated financial threats: physical risks from weather and temperature extremes; transition risks from policy shifts, technological change, and market revaluation; and liability risks emerging from litigation and attribution science. Each of these dimensions is transmitted into the financial system via complex channels, affecting credit, market, and operational stability.

Financial institutions are increasingly exposed through their balance sheets, insurance underwriting, asset holdings, and macroeconomic dependencies. Sectors with carbon-intensive business models and regions with limited adaptive capacity, such as the Sahel, Mekong basin, and Arctic permafrost belt, face disproportionate vulnerabilities. Unequal exposure threatens to deepen global economic disparities, exacerbate sovereign distress, and strain the fiscal capacity of states.

In response, regulators and supervisors have begun integrating climate risk into macroprudential frameworks. Central banks are incorporating climate considerations into stress tests and scenario planning. Institutional investors are realigning portfolios to decarbonization pathways, while financial innovation is expanding through green bonds, catastrophe-linked securities, and blended finance.

To avoid compounding financial fragility and social instability, stakeholders must integrate climate risk into governance, capital allocation, and strategic foresight. Early adaptation, data transparency, and international coordination are essential. The findings of this report offer a roadmap for institutional resilience and just transition, built on rigorous data, financial modeling, and global collaboration.

1. Introduction: Climate Risk as a Systemic Financial and Societal Threat

Climate change has evolved from an environmental issue to a profound and systemic threat to global economic and financial stability. The intensifying frequency and severity of climate-related events – ranging from rising sea levels and chronic droughts to heatwaves and floods – are disrupting ecosystems, damaging infrastructure, displacing populations, and altering production systems. These changes present growing risks not only to biodiversity and human wellbeing but also to the foundations of financial systems and global development. As these

risks mount, they can directly undermine asset valuations, threaten macroeconomic stability, and stress the fiscal and regulatory capacity of governments and institutions.

At the same time, the global response to climate change, through policies aimed at mitigation and decarbonization, is generating transition risks. These include shifts in regulation, changes in consumer preferences, reallocation of capital, and emerging technologies that disrupt traditional business models. When unmanaged, these forces can trigger abrupt asset repricing, stranded assets, and rising credit risk, particularly in carbon-intensive sectors and vulnerable regions. Liability risks are also increasing, as firms, governments, and financial intermediaries face rising exposure to climate-related litigation and reputational pressure.

This report examines the transmission channels through which physical, transition, and liability risks impact the financial system. It assesses how these risks interact with institutional portfolios, balance sheets, and public policy frameworks. Particular attention is given to geographic and sectoral exposure, the evolution of regulatory and supervisory responses, and the role of financial innovation in managing and mitigating risk. Drawing from interdisciplinary research, scenario modeling, and global policy trends, we aim to equip institutional investors, regulators, and policymakers with a comprehensive framework to address the financial dimensions of the climate crisis.

2. Understanding Climate Risks: Physical, Transition, and Liability Dimensions

To build institutional resilience and allocate capital effectively in a warming world, financial actors must first distinguish among the three primary categories of climate-related risk: physical risks, transition risks, and liability risks. Each category affects different sectors and regions through distinct but interconnected channels. Understanding their characteristics, timelines, and interaction points is critical for financial institutions, regulators, and policymakers.

2.1 Physical Risks: The Rising Cost of Extreme Events and Slow-Onset Changes

Physical risks refer to the direct impacts of climate change on natural and built environments. These risks are typically classified into two subtypes:

- Acute risks, such as tropical cyclones, wildfires, flash floods, and heatwaves, which occur suddenly and with increasing frequency.

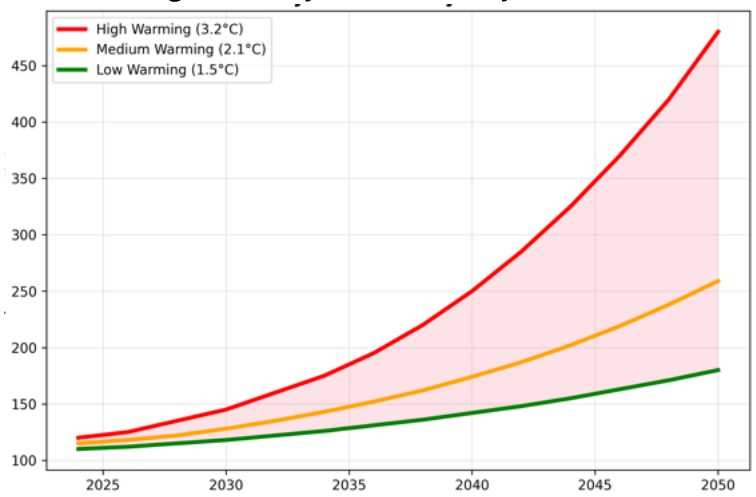
- Chronic risks, including long-term shifts in temperature, precipitation patterns, and sea level, which gradually degrade the conditions for habitation, agriculture, and infrastructure stability.

The economic and human toll of these risks is already mounting. According to Munich Re (2024), global insured losses from weather-related disasters exceeded USD 120 billion in 2023 alone, driven by a record number of billion-dollar floods and wildfire events. The IPCC warns that with each additional degree of warming, the probability of compound climate extremes increases non-linearly, meaning cascading failures across systems, including power grids, transport, water, and health, are becoming more probable.

Physical risks are also location-dependent and unequally distributed. Low-lying countries such as Bangladesh, Pacific Island nations like Tuvalu, and coastal megacities including Jakarta and Lagos face existential risks from sea level rise and salinization. In arid and semi-arid regions like the Sahel, climate variability threatens food and water security, exacerbating fragility and displacement. These risks impair asset valuations, heighten sovereign credit risks, and strain fiscal balances in countries already contending with development deficits.

To illustrate the potential effects of climate change on an institutional investment portfolio, Figure 1 reports the potential estimates costs related to physical risks under three alternative temperature scenarios. The figure shows the exponential increase in losses as temperature rises.

Figure 1. Physical Risk Projections



Source: *Own simulations based on a $2.1 trillion institutional portfolio*.

2.2 Transition Risks: Shocks from the Shift to a Low-Carbon Economy

Transition risks arise from the process of adjusting to a low-carbon economy. These include:

- **Policy and regulatory changes**, such as carbon pricing, emissions caps, and disclosure mandates.

- **Technological shifts**, where low-emission alternatives outcompete legacy systems.

- **Market and reputational dynamics**, including changes in consumer behavior, investor expectations, and litigation trends.

These risks are particularly acute for carbon-intensive sectors such as coal, oil and gas, steel, cement, and automotive manufacturing. For example, the International Energy Agency (IEA, 2023) estimates that over USD 1.3 trillion in fossil fuel assets could become stranded by 2050 under net-zero scenarios. Sudden shifts in regulation or technology, often referred to as "carbon shocks", can lead to abrupt repricing of assets, bankruptcies, and contagion across financial markets.

Financial institutions are exposed both directly (through lending and equity holdings in at-risk firms) and indirectly (via macroeconomic volatility, sectoral employment shifts, and sovereign balance sheets). Investors holding passive index portfolios may face hidden exposure to transition risk through embedded emissions in high-weight sectors, even in the absence of active carbon investment strategies.

2.3 Liability Risks: Legal and Fiduciary Exposure

Liability risks refer to the legal consequences for institutions, firms, or governments deemed to have failed in their duty of care with respect to climate risk. This can involve:

- **Litigation from investors or clients** for inadequate disclosure or failure to incorporate material climate risk in investment decisions.

- **Claims from affected communities or stakeholders** for damage resulting from environmental harm.

- **Regulatory enforcement actions** against misleading sustainability claims or "greenwashing."

The rise in climate litigation is striking. According to the Grantham Research Institute (2024), over 2,500 climate-related lawsuits have been filed globally, with a growing share targeting corporations and financial entities for inadequate risk governance or misleading disclosures. Notable cases, such as *Milieudefensie et al. versus Royal Dutch Shell* and recent suits against global asset managers, suggest a shift toward liability exposure for failing to meet net-zero commitments or comply with evolving standards.

In the financial sector, fiduciary duties are being reinterpreted to include climate risk. In markets like the UK, Canada, and parts of the EU, financial institutions may face enforcement actions if they neglect material climate exposures in portfolio construction, credit risk assessment, or client advisory services. The implications extend to directors' duties, insurance underwriting, and public sector procurement.

3. Transmission Channels into the Financial System

Climate-related risks enter the financial system through multiple, interdependent channels that affect asset values, credit quality, liquidity conditions, and overall market confidence. These transmission mechanisms are complex, systemic, and often nonlinear—meaning that even localized climate events or policy shifts can generate ripple effects across global financial networks. Understanding these pathways is essential for institutions aiming to identify exposures, quantify risks, and allocate capital in a climate-informed manner.

3.1 Transmission Mechanisms by Risk Type

Physical risks damage physical capital (e.g., buildings, factories, infrastructure), disrupt supply chains, reduce labor productivity, and trigger humanitarian emergencies. These impacts translate into increased insurance claims, credit losses, and sovereign risk, especially in countries lacking adaptive infrastructure or fiscal space for recovery. For instance, Hurricane Ian in 2022 resulted in over USD 60 billion in insured damages in the United States alone, contributing to one of the largest quarterly losses in the global property and casualty sector (Swiss Re Institute, 2023).

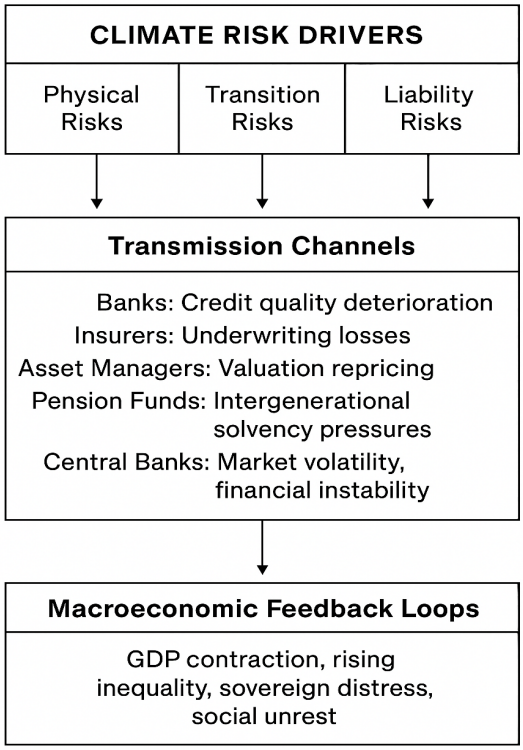
Transition risks affect financial markets through sudden asset repricing, policy shocks, and technological obsolescence. A shift in carbon pricing or emissions standards can lead to widespread downgrades of debt instruments tied to carbon-intensive sectors. For example, the imposition of the EU Carbon Border Adjustment Mechanism (CBAM) is expected to impact exporters in steel, aluminum, and fertilizer sectors across emerging markets, with potential downstream credit impacts on sovereign and corporate issuers (European Commission, 2023).

Liability risks expose institutions to financial losses through lawsuits, regulatory fines, and reputational damage. Greenwashing scandals or ESG misstatements can trigger legal action or capital withdrawal, as seen in high-profile investigations of several asset managers and banks in recent years.

3.2 Climate Risk Transmission Channels into Financial Institutions

To visualize the multifaceted nature of climate-related financial risks, Figure 2 provides a diagram that maps the transmission of physical, transition, and liability risks into and across different types of financial institutions. It illustrates how these risks originate from environmental or policy drivers, penetrate institutional balance sheets, and ultimately propagate systemic feedback loops that affect macroeconomic performance and societal stability. This conceptual framework is not exhaustive, but it highlights the interdependencies that characterize climate risk in the financial system.

Figure 2. Climate Risk Transmission Channels into Financial Institutions



Source: *Bank and Finance, McKinsey Global Institute (2020),*

3.3 Illustrative Transmission Channels by Financial Sector

To operationalize how climate risks map onto financial institutions, Table 1, below, provides a comparative view of the three main risk types – physical, transition, and liability – across core segments of the financial system. The purpose is to help practitioners assess where risks are likely to manifest in portfolios, balance sheets, and operational processes, and to identify where mitigation or adaptation strategies should be prioritized.

3.4 Systemic Amplifiers and Feedback Loops

The impacts of climate risks on financial institutions are compounded by structural amplifiers:

- **High leverage** amplifies the sensitivity of institutions to asset repricing.
- **Market herd behavior** accelerates selloffs in high-risk sectors during transition shocks.
- **Data and model gaps** limit the ability to accurately price risk, leading to undercapitalization or misallocation.

- **Cross-border spillovers**, such as supply chain disruptions or migration-induced fiscal stress, introduce second-order effects.

Furthermore, the feedback loop between financial stress and real economic outcomes can intensify social and political risks. A sequence of disasters leading to credit tightening and fiscal contraction can drive inequality, fuel unrest, and further weaken the investment environment, particularly in frontier markets with limited resilience capacity.

Table 1. Illustrative Transmission Channels by Financial Sector

Financial Sector	Exposure to Physical Risk	Exposure to Transition Risk	Exposure to Liability Risk
Banks	Mortgage defaults due to flood/fire damage; loan book impairment	Stranded assets in carbon-intensive sectors; credit rating downgrades	Litigation for failing to assess ESG risk; reputational damage
Insurers	Surge in claims; reinsurance repricing; capital adequacy pressure	Portfolio exposure to fossil fuel firms; reputational risk	Lawsuits over misleading climate disclosures; supervisory fines
Asset Managers	NAV volatility due to disaster-affected holdings	Portfolio misalignment with net-zero targets; exclusion from mandates	Legal claims from beneficiaries over fiduciary failure
Pension Funds	Long-term liability mismatch; value erosion in real assets	Exposure to climate-unaligned investments; stranded asset risk	Regulatory sanctions over non-compliance with climate disclosure rules
Sovereign Debt Markets	Higher default risk from climate-vulnerable countries	Reduced market access for carbon-intensive sovereigns	Investor litigation tied to climate risk mispricing in sovereign ratings
Central Banks	Collateral risk from climate-impacted assets	Monetary policy transmission distortion; financial system instability	Legal challenges to monetary frameworks lacking climate integration

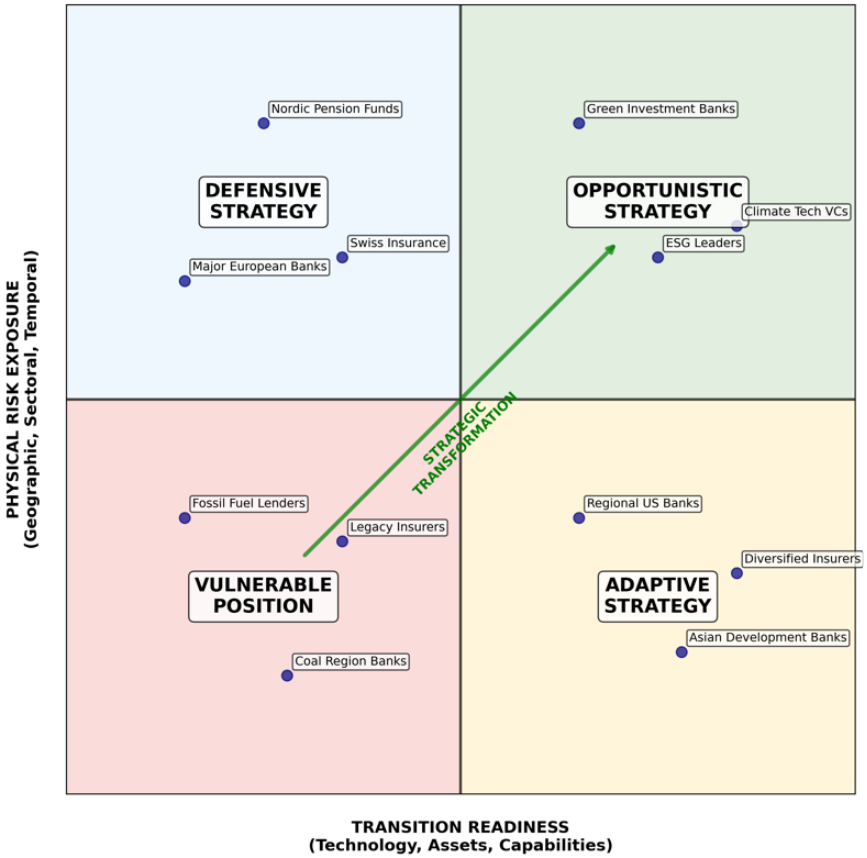
Sources: NGFS (2022), IMF (2023), ECB (2022), Grantham Institute (2024)

3.5 Climate Risk Navigator

Our proprietary Climate Risk Navigator provides a strategic positioning tool that maps financial institutions across two critical dimensions: physical risk exposure and transition risk exposure.

This framework enables executives to understand their current risk profile and identify optimal strategic positioning for long-term value creation.

Figure 3. The Climate Risk Navigator: Strategic Positioning Framework for Financial Institutions



Source: *Bank and Finance*.

Institutions with minimal physical and transition risk exposure are positioned for sustainable growth and premium valuations. They are likely to have higher returns on equity than industry average, lower cost of capital and faster growth in ESG-focused products. Meanwhile, institutions facing dual exposure require immediate strategic transformation and risk mitigation. Otherwise, they are likely to exhibit higher volatility in earnings, lower valuations and increasing regulatory scrutiny.

4. Sectoral and Geographic Exposure Analysis

Climate-related financial risks do not affect all sectors and regions equally. Their distribution is shaped by factors such as geography, economic structure, institutional capacity, climate vulnerability, and adaptive readiness. In this section, we examine which industries and countries are most exposed—either to physical risks, transition dynamics, or both—and why.

This analysis provides a foundation for financial institutions and policymakers to prioritize risk assessments, stress testing, and capital reallocation.

4.1 Sectoral Vulnerability: High-Emission, High-Exposure Industries

Sectors vary in their exposure based on their carbon intensity, supply chain sensitivity, asset lifespans, and regulatory visibility. Carbon-intensive industries, such as oil and gas, utilities, mining, cement, and automobiles, face pronounced transition risk, decarbonization targets, emissions pricing, and technological substitution accelerate. In contrast, sectors like agriculture, construction, transport, and tourism often face combined physical and economic risks due to climate-sensitive operations and geographic dependence. Table 2, below, classifies selected sectors by their relative exposure to physical and transition risks.

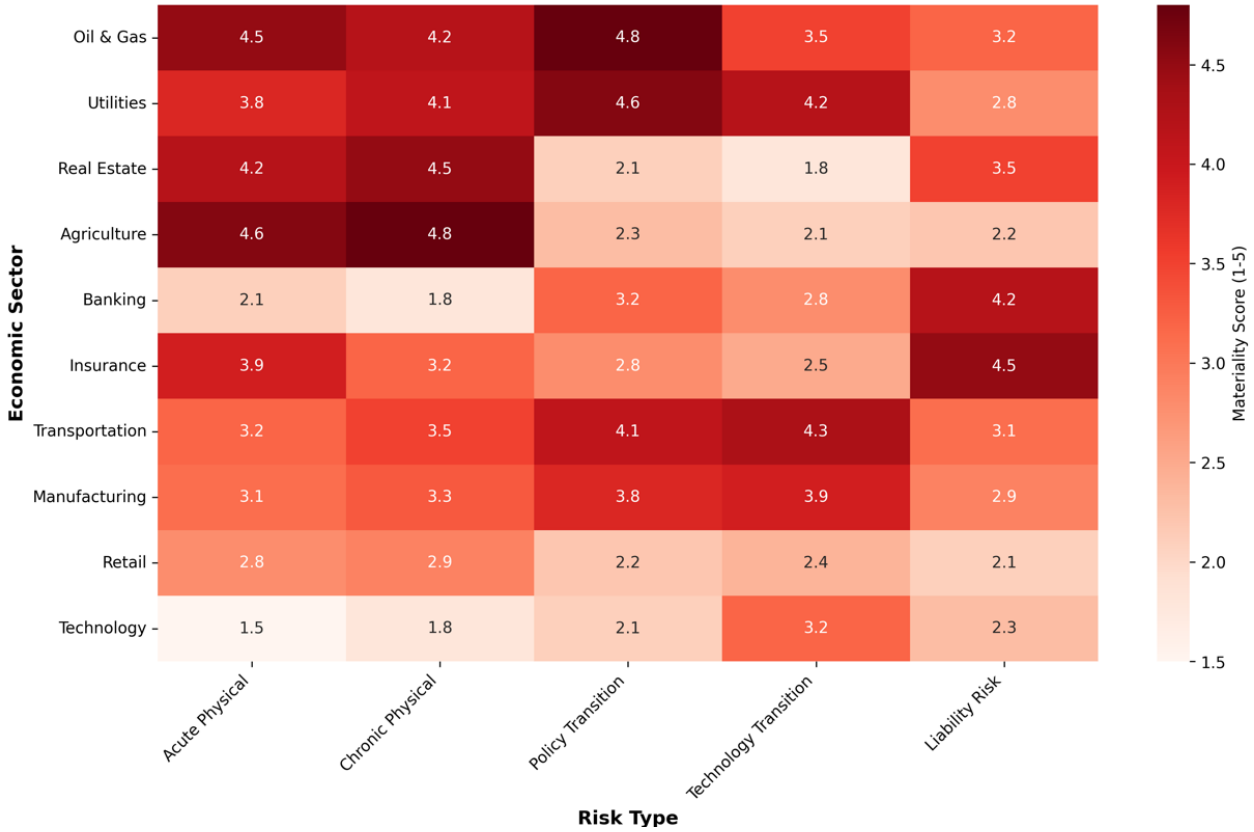
Table 2. Sectoral Risk Matrix: Physical vs. Transition Risk Exposure

Sector	Transition Risk Exposure	Physical Risk Exposure	Comments
Oil & Gas	High	Medium	Subject to stranded assets and carbon pricing
Utilities (coal-fired)	High	Medium	Exposure to both transition and infrastructure disruption
Agriculture	Medium	High	Highly sensitive to drought, heat, floods
Real Estate	Medium	High	Physical assets exposed in coastal and flood-prone zones
Tourism & Hospitality	Medium	High	Vulnerable to heat, storms, and biodiversity loss
Transport & Logistics	Medium	Medium	Infrastructure exposure; emissions regulation impacts
Mining & Metals	High	Medium	Carbon intensity and exposure to water stress
Cement	High	Low	Major industrial emitter with long-lived capital assets
Financial Services	Medium	Medium	Indirect exposure through portfolios and counterparties
Information Technology	Low	Low	Less direct exposure, though rising scrutiny on data center energy use

***Sources**: IEA (2023), NGFS (2022), McKinsey Global Institute (2020), World Resources Institute (2023)*

Figure 4 complements this table by showing the climate risk materiality assessment by sector. Physical, transition and liability risks are measured. Materiality of risks are given a score on a 1 to 5 scale, with higher risk as the number increases.

Figure 4. Climate Risk Materiality Assessment by Sector



Sources: Bank and Finance, IEA (2023), NGFS (2022), McKinsey Global Institute (2020), World Resources Institute (2023)

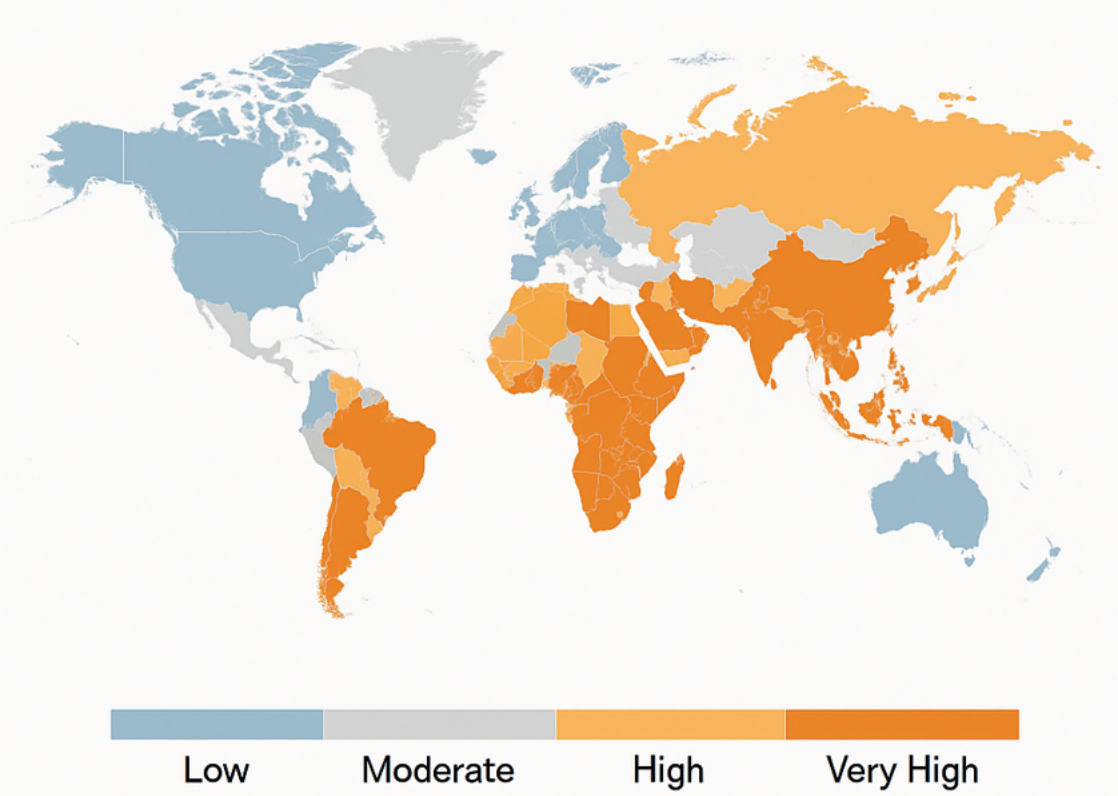
4.2 Geographic Exposure: Climate Risk Hotspots and Adaptive Capacity

Climate vulnerability is highly location-dependent. It is shaped not only by physical exposure (e.g., flood plains, arid zones, coastal proximity), but also by the adaptive capacity of governments, households, and financial systems. Countries with fragile governance, high poverty rates, limited fiscal space, and dependence on climate-sensitive sectors are particularly at risk.

The Notre Dame Global Adaptation Initiative (ND-GAIN) index and the World Bank's Climate Change Knowledge Portal consistently identify high-risk countries across Sub-Saharan Africa, South Asia, Southeast Asia, and small island developing states (SIDS). In contrast, some advanced economies face elevated transition risk due to carbon-intensive production structures and ambitious regulatory targets (e.g., Germany's heavy industry, Canada's tar sands, or Japan's auto exports).

Figure 5 provides a global heatmap of climate-related financial vulnerability, integrating both exposure and readiness dimensions.

Figure 5. Global Climate Financial Vulnerability Heatmap



Sources: *ND-GAIN Index (2023) and World Bank Climate Data (2023).*

4.3 Most Vulnerable Countries: Multidimensional Exposure Profiles

Below, Table 3 highlights a selection of countries that exhibit high vulnerability based on multiple risk vectors: exposure to extreme weather, economic reliance on climate-sensitive sectors, limited institutional capacity, and low financial resilience. This typology is useful for investors managing sovereign risk, banks evaluating credit exposure, and insurers assessing underwriting strategy.

4.4 Regional Disparities and Inequality of Exposure

Even within countries, climate risks are unequally distributed. Low-income communities, informal settlements, and Indigenous populations often reside in high-exposure zones (e.g., floodplains, heat islands), with limited access to insurance, savings, or political voice. In high-income countries, vulnerable groups may still experience disproportionate exposure, for

example, elderly populations during heatwaves in Europe, or minority communities affected by hurricane flooding in the United States.

Table 3. Countries with High Multidimensional Climate Risk Exposure

Country	Primary Risk Type	Key Drivers of Vulnerability	Implications for Financial Risk
Bangladesh	Physical	Sea level rise, riverine flooding, dense coastal population	Rising insurance claims, sovereign credit downgrade risk
Nigeria	Mixed	Oil dependency, water stress, urban heat	Stranded fossil assets, food security shocks, inflation
Vietnam	Physical + Transition	Coastal exposure, manufacturing exports under CBAM	Supply chain disruption, sovereign spread volatility
Pakistan	Physical	Glacier melt, flood plains, limited fiscal space	Infrastructure damage, banking sector solvency pressure
Philippines	Physical	Frequent typhoons, informal housing in risk-prone areas	Credit default risk, microfinance strain
Indonesia	Transition + Liability	Forest loss, palm oil scrutiny, litigation risk	ESG divestment, rising cost of capital
Small Island States (e.g., Fiji, Bahamas)	Physical	Sea level rise, tourism exposure	Tourism revenue loss, insurance retreat from property markets
India	Mixed	Extreme heat, agriculture reliance, air quality regulations	Heat stress on labor productivity, rising NPLs in rural finance
Egypt	Transition	Emissions-intensive cement and energy sectors, water scarcity	Export barriers, infrastructure obsolescence
South Africa	Transition + Liability	Coal-based power, energy-intensive industry, ESG activism	Carbon tax exposure, corporate credit downgrades

Sources: *ND-GAIN Index (2023), World Bank Climate Data (2023), IMF Climate Risk Assessment Tool (2024), NGFS (2023)*

This spatial and socio-economic disparity underscores the distributional nature of climate risk. Financial institutions with geographically diversified portfolios must account for intra-national heterogeneity. Similarly, governments and development banks need to consider how infrastructure investment and risk pooling mechanisms can be targeted to reduce inequality in exposure.

5. Evolving Regulatory and Disclosure Landscape

As climate change reshapes global financial risk, regulatory and disclosure frameworks are rapidly evolving to ensure that institutions, investors, and markets integrate climate

considerations into their decision-making processes. These frameworks aim to improve transparency, reduce systemic risk, and support the transition toward a low-carbon economy. Regulatory momentum has accelerated in recent years, driven by the combined influence of international initiatives, market forces, and litigation risk.

5.1 From Disclosure to Supervision: The Expanding Scope of Climate Regulation

Climate-related disclosures have moved from voluntary best practice to regulatory imperative. The Task Force on Climate-related Financial Disclosures (TCFD), established by the Financial Stability Board in 2015, set the global benchmark. Its framework – centered on governance, strategy, risk management, and metrics and targets – has been adopted or referenced by over 4,000 organizations worldwide (FSB, 2023). Building on this foundation, the International Sustainability Standards Board (ISSB) issued its first climate-focused disclosure standards (IFRS S1 and IFRS S2) in 2023, setting a global baseline for consistent sustainability reporting.

Regional regulators have responded by embedding these standards into domestic legislation. The European Union's Sustainable Finance Disclosure Regulation (SFDR) and EU Taxonomy mandate granular reporting on sustainable activities, portfolio alignment, and adverse impacts. In the United States, the Securities and Exchange Commission (SEC) has proposed rules requiring Scope 1 and 2 emissions disclosure for all listed firms, with Scope 3 emissions reporting for large filers and when material. Other jurisdictions, including Canada, Japan, and Australia, are aligning with the TCFD or ISSB frameworks while adapting them to national contexts.

At the same time, financial supervisors are incorporating climate considerations into prudential oversight and macroprudential stress testing. The Network for Greening the Financial System (NGFS), now comprising over 125 central banks and supervisors, has developed a suite of climate risk scenarios used by institutions to assess balance sheet vulnerabilities. The European Central Bank (ECB), Bank of England (BoE), and Bank of Japan have piloted forward-looking climate stress tests. The ECB's 2022 climate stress test, for example, showed that euro-area banks could face losses of up to €70 billion annually by 2050 under high-warming scenarios, particularly through exposure to energy and real estate portfolios (ECB, 2022).

In parallel, anti-greenwashing regulation and liability enforcement have emerged as critical priorities. Regulators and civil society are scrutinizing firms for misleading sustainability claims or failure to follow through on net-zero commitments. The EU Green Claims Directive requires companies to substantiate environmental claims with verifiable evidence. In the United States, the SEC has launched investigations into asset managers suspected of exaggerating ESG integration in their products. Globally, legal risks for misstatements in climate disclosures or omissions in fiduciary duties are rising, with litigation targeting both companies and financial institutions.

These developments reflect a shift in regulatory philosophy: climate risk is no longer considered a purely reputational matter, it is now treated as a material financial risk subject to disclosure, supervision, and legal accountability.

5.2 Key Climate-Related Frameworks

The following table summarizes the most influential international and regional frameworks currently shaping climate-related financial governance.

Table 4. Key Climate-Related Disclosure and Regulatory Frameworks

Framework / Regulation	Scope	Key Features	Geographic Coverage
TCFD (Task Force on Climate-related Financial Disclosures)	Voluntary (baseline for many jurisdictions)	Focus on governance, strategy, metrics, risk analysis	Global
ISSB Standards (IFRS S1 & S2)	Global baseline (adopted by many jurisdictions)	Scenario analysis, transition plans, financial metrics	Global
EU SFDR & EU Taxonomy	Mandatory for EU funds and financial products	Classification of sustainable activities, impact disclosures	EU
U.S. SEC Climate Disclosure Rules	Proposed mandatory disclosures for listed companies	Scope 1 & 2 emissions, Scope 3 for large filers	U.S.
NGFS Climate Scenarios	Guidance for central banks and supervisors	Physical and transition risk scenario analysis	Global
Green Claims Directive (EU)	Consumer protection & anti-greenwashing	Verification of sustainability claims	EU
BoE/ECB Climate Stress Tests	Prudential supervision for banks and insurers	Forward-looking climate risk modeling	UK, Eurozone

Sources: *TCFD (2023), ISSB (2023), ECB (2022), SEC (2023), NGFS (2022), European Commission (2023)*

6. Investor and Institutional Response

As climate risks become increasingly material to portfolios, liabilities, and business models, financial institutions around the world are moving to incorporate climate considerations into their strategic planning, governance frameworks, and investment processes. This institutional response is being driven not only by regulation but also by mounting evidence that climate-related events and policies are reshaping asset values, operating costs, and long-term financial returns.

Institutional investors, particularly pension funds, sovereign wealth funds, and insurance companies, are among the most exposed to long-dated risks associated with climate change. Many have begun aligning their portfolios with net-zero objectives, integrating climate scenarios into risk management, and engaging with portfolio companies on transition planning. For example, the Net-Zero Asset Owner Alliance (NZAOA), representing over USD 11 trillion in assets under management (AUM), has committed to reducing portfolio emissions by 25–30% by 2025 from a 2019 baseline.

Asset managers are deploying a range of tools to assess and mitigate climate risk. These include climate value-at-risk (VaR) models, carbon footprinting, and internal heatmaps of transition exposure. Some have introduced climate-themed investment products, such as green bond funds and transition equity portfolios. Others are expanding stewardship efforts by filing shareholder resolutions and voting against boards of companies that lag on climate disclosure or decarbonization.

Banks and insurers are embedding climate risk into credit underwriting, pricing, and reinsurance strategies. Leading institutions such as HSBC, AXA, and Allianz have developed science-based targets, published sector-specific lending policies, and begun stress-testing their balance sheets against climate scenarios. For example, Swiss Re has revised its risk appetite for wildfire-prone areas and is piloting parametric insurance products for flood-prone regions.

Central banks and financial supervisors are also recalibrating their role. Some are incorporating climate factors into monetary operations (e.g., the Bank of England's green corporate bond purchases), while others are integrating climate risk into capital adequacy frameworks and macroprudential buffers. The ECB, BoE, and Banque de France are experimenting with climate-adjusted collateral frameworks and green discount windows.

While progress is uneven, the institutional landscape is rapidly evolving. Table 5 provides a synthesized view of how different categories of financial institutions are responding to climate risk.

Despite this momentum, challenges remain. Many institutions continue to struggle with:

- Inadequate data on asset-level emissions, physical exposure, and supply chain vulnerabilities;
- Scenario uncertainty, particularly in modeling non-linear climate responses;
- Operational complexity, including aligning risk, compliance, and product teams around climate priorities;
- Incentive misalignment, especially in institutions with short-term performance horizons.

Nonetheless, the directional shift is clear: climate considerations are moving from the periphery to the core of financial decision-making. In the next section, we turn to the expanding toolkit of financial innovation that supports both climate resilience and the low-carbon transition.

Table 5. Institutional Strategies to Address Climate Risk

Institution Type	Key Climate Risk Responses	Examples
Asset Owners	Portfolio emissions targets, climate scenario analysis, ESG integration in mandates	Net-Zero Asset Owner Alliance, CalPERS, GPIF
Asset Managers	Carbon VaR modeling, green funds, engagement strategies, climate voting policies	BlackRock, Amundi, Legal & General Investment Management (LGIM)
Banks	Sectoral credit policies, financed emissions tracking, climate stress testing	HSBC, Citi, BBVA, ING
Insurers	Repricing catastrophe risk, portfolio decarbonization, underwriting exclusions	Swiss Re, Munich Re, AXA, Allianz
Central Banks	Climate scenario analysis, green collateral policy, integration into monetary operations	ECB, Bank of England, Banque de France
Development Finance Institutions	Climate finance mobilization, concessional lending for adaptation, blended finance instruments	IFC, EIB, Green Climate Fund, IDB

Sources: PRI (2024), UNEP FI (2023), ECB (2023), BoE (2023), NZAOA (2023), Swiss Re (2023), CDP (2024)

7. Financial Innovation for Climate Resilience and Transition

The evolving landscape of climate risk has catalyzed a wave of financial innovation aimed at both mitigating exposure and facilitating investment in climate-resilient and low-carbon solutions. Financial markets are increasingly recognizing that addressing climate change is not only a risk management imperative, but also a source of value creation and competitive advantage.

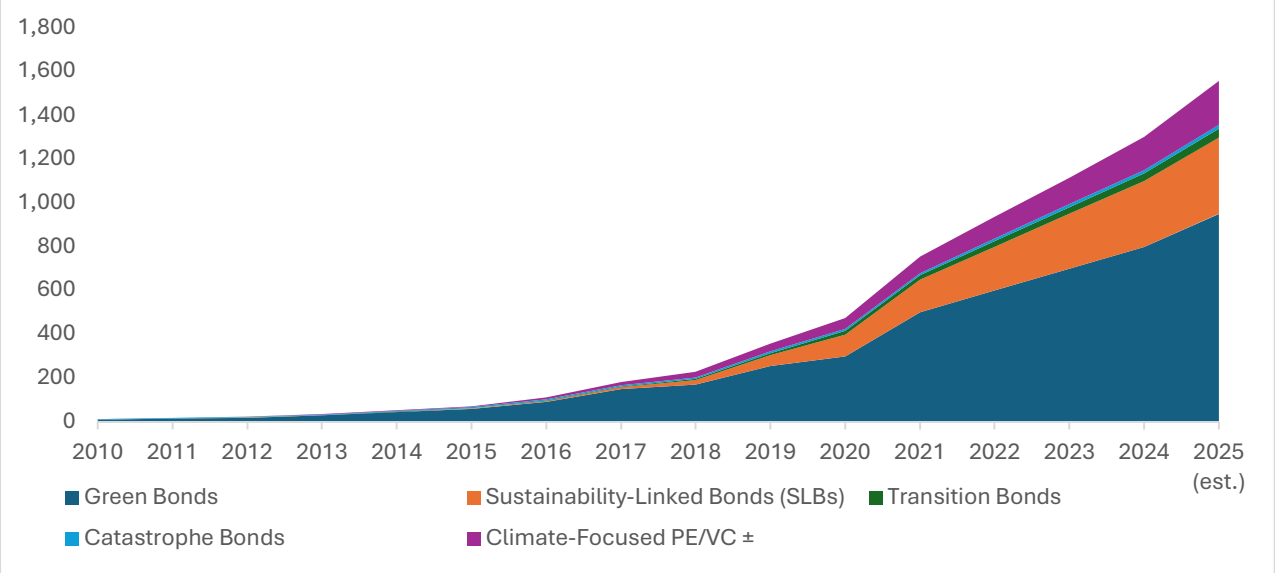
This innovation has taken the form of new asset classes, structured finance instruments, insurance mechanisms, and blended finance vehicles that channel capital into mitigation, adaptation, and resilience. These instruments help overcome market failures such as information asymmetry, short-termism, and mispricing of externalities, which historically limited investment in sustainable infrastructure and technologies.

7.1 Growth in Climate-Linked Financial Instruments

The most prominent financial innovation has been the rise of green bonds, which reached cumulative global issuance of over USD 2.5 trillion by 2024 (Climate Bonds Initiative, 2024). These bonds fund projects in renewable energy, clean transport, energy efficiency, and water infrastructure. Sustainability-linked bonds and loans, which tie financing costs to climate performance indicators, are also gaining traction, particularly among corporates and emerging market sovereigns.

Meanwhile, catastrophe bonds (cat bonds) and parametric insurance are expanding the risk transfer toolkit for climate-related losses. These instruments provide pre-agreed payouts based on the occurrence of a climate event (e.g., wind speed, rainfall level), rather than assessed damages. This enables faster recovery and enhances fiscal resilience for both governments and insurers.

Figure 6. Growth of ESG and Climate-Focused Financial Instruments (2010–2025, USD billions)



Sources: Climate Bonds Initiative, BloombergNEF, S&P Global, Swiss Re Institute, and World Bank.

7.2 Taxonomy of Climate-Linked Instruments

While innovation is progressing, the variety and complexity of climate financial instruments pose challenges for standardization, impact verification, and integration into traditional risk management systems. Table 6, below, offers a simplified taxonomy of leading climate-related instruments, categorized by objective and risk type.

Table 6. Climate-Linked Financial Instruments and Risk Transfer Mechanisms

Instrument Type	Primary Objective	Targeted Risk	Key Users	Challenges
Green Bonds	Finance green projects	Transition	Corporates, Sovereigns, Municipalities	Verification, additionality, secondary market liquidity
Sustainability-Linked Bonds/Loans	Incentivize sustainability performance	Transition	Corporates, Banks	KPI integrity, issuer self-selection bias
Transition Bonds	Fund carbon-intensive sectors shifting to low-carbon operations	Transition	Industrial firms, utilities	Greenwashing risk, credibility of transition plans
Catastrophe Bonds	Transfer risk from extreme weather events	Physical	Insurers, Sovereigns	Pricing, basis risk, limited investor base
Parametric Insurance	Provide rapid payouts post-disaster	Physical	Governments, Farmers, SME sectors	Data quality, payout accuracy
Climate Resilience Bonds	Finance adaptation infrastructure	Physical	Municipalities, DFIs	Scarcity of projects, lack of adaptation metrics
Blended Finance (e.g., first-loss capital)	De-risk private capital for climate investment	Mixed	Development banks, Impact investors	Complexity, governance structure

Sources: *Climate Bonds Initiative (2024), UNEP FI (2023), Swiss Re Institute (2024), WRI (2023)*

7.3 Emerging Trends and Outlook

Several key trends are shaping the next phase of climate finance innovation:

- Digital infrastructure enables more granular data for risk modeling and smart contract execution, including blockchain-based climate bonds.
- Nature-based solutions (NbS) are gaining investor attention, leading to instruments such as biodiversity credits and natural capital securitization.
- Climate fintech platforms are democratizing access to green investing and enhancing transparency through real-time emissions tracking.

Yet barriers persist. Regulatory uncertainty, lack of standardized taxonomies, and insufficient project pipelines, especially in adaptation, continue to hinder scale. Nonetheless, climate-aligned finance is expected to exceed USD 10 trillion in cumulative issuance by 2030 (BloombergNEF, 2024), as markets internalize the economic logic of climate risk and opportunity.

8. Strategic Implications for Financial Institutions and Policymakers

The systemic nature of climate risk demands a proactive, integrated response from both financial institutions and public authorities. The convergence of physical hazards, transition disruptions, and legal liabilities presents not only a multidimensional risk landscape, but also an opportunity to reshape the financial system for long-term sustainability and resilience. This section outlines the strategic implications for institutional investors, banks, insurers, central banks, and policymakers, based on the analysis presented in previous sections.

8.1 Institutional Imperatives: Embedding Climate Risk Across the Enterprise

Financial institutions must move beyond high-level ESG statements toward operational integration of climate risk across governance, strategy, risk management, and disclosure. This entails:

- **Risk identification and quantification**: Institutions should adopt climate-adjusted models for credit, market, and insurance risk. This includes integrating physical risk exposure into property and infrastructure valuations, and stress testing balance sheets under NGFS climate scenarios.

- **Portfolio realignment**: Long-term capital allocation decisions must consider climate transition pathways. This includes reducing exposure to stranded assets, scaling investment in clean technologies and resilience infrastructure, and reweighting sovereign portfolios to reflect climate vulnerability and adaptation capacity.

- **Client and counterparty engagement**: Financial institutions are increasingly expected to serve as transition partners for their clients. This involves supporting climate disclosure, offering sustainability-linked financing products, and advising on decarbonization strategies, particularly for SMEs and emerging markets.

- **Data governance and reporting**: Institutions must build internal capacity for sourcing, verifying, and interpreting climate-related data. Adoption of ISSB or TCFD-aligned disclosure standards should be institutionalized, not treated as compliance afterthought.

- **Talent and incentives**: Building climate capability requires upskilling across investment, risk, compliance, and IT functions. Incentive structures—such as remuneration, promotion, and product development—should align with long-term climate and sustainability goals.

8.2 Policymaker Priorities: Aligning Regulation with Resilience and Transition

Policymakers and financial supervisors have a crucial role to play in shaping an enabling environment for climate-aligned finance. Key priorities include:

- **Regulatory clarity and convergence**: Harmonization of climate disclosure frameworks, taxonomies, and transition benchmarks across jurisdictions is essential to reduce fragmentation, regulatory arbitrage, and greenwashing. The ISSB and EU SFDR provide important baselines for convergence.

- **Climate-informed prudential regulation**: Central banks and supervisors should continue integrating climate risk into capital adequacy, solvency rules, and supervisory expectations. This includes embedding climate risk into stress testing, collateral frameworks, and systemic risk surveillance.

- **Fiscal and blended finance strategies**: Public finance must play a catalytic role in crowding in private capital, particularly in adaptation and emerging markets. Blended finance structures, first-loss guarantees, and concessional funding should be scaled to de-risk climate-aligned investment.

- **Market infrastructure and transparency**: Investment in high-quality climate data infrastructure – such as open-source emissions databases, adaptation metrics, and geospatial risk tools – can enhance transparency, reduce transaction costs, and support informed decision-making.

- **Just transition considerations**: Public policy must ensure that the climate transition does not exacerbate social or regional inequalities. This requires targeted support for vulnerable workers, regions, and industries, and proactive use of public finance to ensure inclusive growth.

8.3 Strategic Outlook

Climate risk is dynamic and path-dependent. Financial institutions that fail to adapt risk material losses, reputational damage, and regulatory sanction. Conversely, those that integrate climate considerations holistically across their operations are likely to gain strategic advantage – not just through risk mitigation, but by capturing value from innovation, client engagement, and capital reallocation toward sustainability.

For policymakers, the imperative is to ensure that regulatory frameworks, market signals, and financial incentives align with climate objectives. Doing so will require long-term vision, institutional coordination, and investment in enabling infrastructure.

As the climate challenge intensifies, the integration of climate risk into financial decision-making is no longer optional, it is foundational to preserving value, managing volatility, and ensuring a stable transition to a low-carbon, resilient global economy.

9. Risk Mitigation and Adaptive Capacity Building

While recognizing climate risk is a critical first step, effective management depends on the ability of institutions and financial systems to build resilience – not only to withstand shocks, but also to adapt and evolve in response to a changing risk landscape. This section outlines practical approaches to mitigating climate-related risks and strengthening adaptive capacity, drawing on emerging best practices across the financial sector.

9.1 Institutional Resilience: Strengthening Internal Capabilities

Financial institutions must embed resilience strategies into their core risk management and governance frameworks. Key priorities include:

- **Climate scenario analysis**: Conducting multi-horizon, multi-scenario stress tests across portfolios to identify vulnerabilities under different physical and transition pathways. The NGFS, ECB, and BoE provide reference scenarios and methodological guidance.

- **Exposure mapping**: Integrating asset-level geospatial data into internal systems to assess exposure to physical hazards (e.g., floods, wildfires, sea level rise) and transition hotspots (e.g., fossil fuel regions, carbon-intensive sectors).

- **Insurance and risk transfer tools**: Reassessing underwriting criteria, reinsurance arrangements, and catastrophe modeling to reflect changing hazard patterns. For non-insurers, hedging instruments and contingent credit lines may offer buffer capacity.

- **Contingency planning**: Developing forward-looking business continuity plans that account for climate-triggered disruptions, including asset impairment, supply chain failures, and mass migration or displacement events.

- **Board-level oversight**: Assigning formal responsibility for climate risk to board committees or dedicated executives, supported by clear mandates and performance metrics. Effective oversight requires integration into enterprise risk management (ERM) and audit functions.

9.2 Systemic Resilience: Supporting Market-Wide Adaptation

Systemic resilience depends on a supportive ecosystem that aligns market incentives with climate goals. Key components include:

- **Disclosure alignment**: Promoting interoperability between global climate reporting standards (e.g., ISSB, EU CSRD, U.S. SEC rules), to reduce reporting burden and increase comparability of risk disclosures.

- **Financial inclusion and protection**: Ensuring that climate adaptation does not widen access gaps. This includes expanding microinsurance, parametric coverage, and credit guarantees for vulnerable populations, especially in emerging markets.

- **Public-private partnerships (PPPs)**: Leveraging blended finance structures and technical assistance to scale adaptation infrastructure, such as flood barriers, urban cooling systems, and resilient agriculture.

- **Supervisory coordination**: Enhancing cross-border coordination among financial supervisors to address spillover risks from climate-related shocks, particularly for internationally active banks and insurers.

9.3 Summary of Mitigation Strategies by Sector

Table 7, below, summarizes recommended mitigation strategies tailored to different segments of the financial system.

Table 7. Climate Risk Mitigation Strategies by Financial Sector

Sector	Key Mitigation Strategies
Banks	Climate-adjusted credit risk models, carbon exposure limits, green lending frameworks
Insurers	Revised catastrophe modeling, premium repricing, exclusion zones, parametric coverage
Asset Managers	Climate risk scoring of holdings, portfolio tilting, engagement on transition pathways
Pension Funds	Climate scenario stress testing, long-term asset-liability modeling, green infrastructure allocation
Central Banks	Climate-aligned collateral frameworks, integration of climate risk into prudential buffers
DFIs and MDBs	Concessional finance for resilience, technical assistance, risk-sharing for adaptation
Regulators	Supervisory guidance on climate risk governance, systemic stress tests, greenwashing enforcement

Sources: NGFS (2023), UNEP FI (2023), PRI (2024), IMF (2023), Swiss Re Institute (2024)

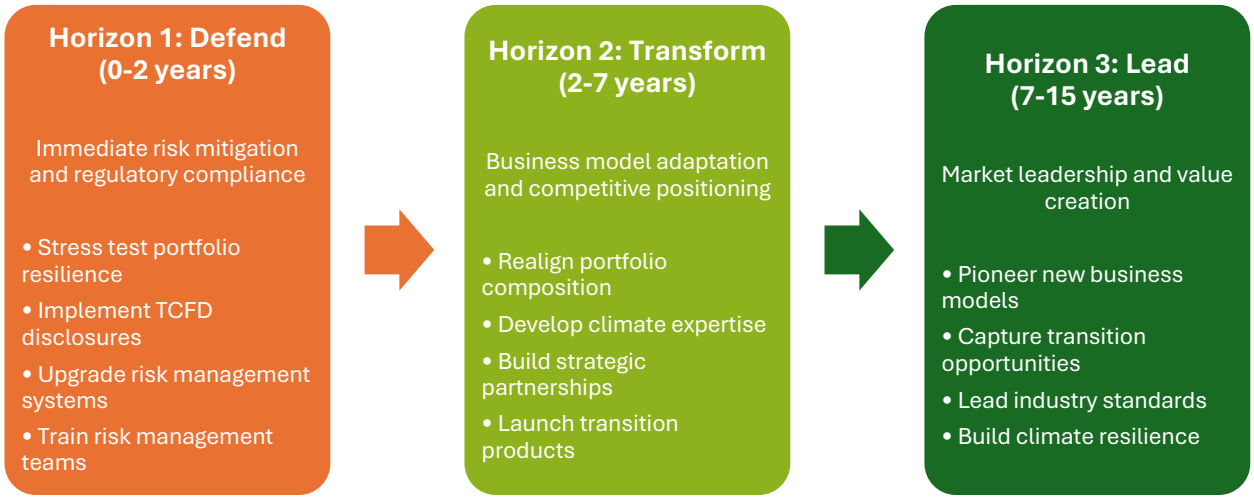
9.4 Capacity Gaps and Technical Assistance Needs

Despite growing awareness, many institutions, particularly in low-income and emerging markets, face acute constraints in data availability, modeling capacity, and institutional readiness. Technical assistance and knowledge-sharing platforms are essential to bridge these gaps. International financial institutions, development banks, and global initiatives (e.g., the Coalition of Finance Ministers for Climate Action, the V20 Risk Focus Group, and the Global Shield against Climate Risks) play a pivotal role in building climate financial literacy and operational capacity.

9.5 Three-Horizon Climate Strategy

Successful climate risk management requires a multi-horizon approach that balances immediate risk mitigation with long-term transformation and opportunity capture. Our Three-Horizon Framework provides a structured approach to resource allocation and strategic planning across different time dimensions. Figure 7 shows this strategic framework.

Figure 7. Three-Horizon Climate Strategy Framework: Progressive Implementation Roadmap for Financial Institutions



Source: *Bank and Finance*

10. Conclusions and Next Steps

Climate change presents a structural, multi-dimensional, and deeply interlinked set of risks that challenge traditional assumptions in financial analysis, regulation, and investment. The evidence is unequivocal: both acute and chronic climate-related events are accelerating, and the pathways through which they affect financial systems are expanding, from credit quality deterioration and asset repricing to macroeconomic instability and sovereign risk.

Physical, transition, and liability risks are not evenly distributed. Exposure is especially concentrated in geographies with low adaptive capacity and in economic sectors dependent on fossil fuels or vulnerable supply chains. As these risks intensify, they threaten not only financial portfolios but also the foundational elements of human wellbeing – health, livelihoods, social cohesion, and the fiscal integrity of states.

While progress has been made in integrating climate considerations into regulatory frameworks and investor strategies, systemic gaps remain. Disclosures are still uneven, pricing signals insufficient, and capital flows to adaptation solutions limited. Left unaddressed, these gaps could amplify volatility, widen inequality, and undermine the credibility of climate commitments.

The financial sector must act decisively. This means embedding climate risk into governance, scenario planning, and capital allocation; expanding investment in resilience and transition technologies; supporting transitions across sectors and borders; and deepening coordination with public policy frameworks. Regulators and supervisors must accelerate the integration of climate into prudential mandates, and governments must ensure that adaptation finance and climate intelligence reach the most exposed communities and institutions.

Climate risk is now a core financial and strategic consideration. Institutions that lead in integrating climate foresight will be better positioned not only to avoid losses but to shape the financial architecture of a more resilient and equitable future.

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12. Appendices

A. Methodology and Data Sources

This report combines qualitative and quantitative analysis to assess the financial implications of climate change. The research methodology includes:

1. Literature Review

We reviewed over 150 sources, including peer-reviewed academic studies, central bank publications, multilateral reports, market intelligence, and regulatory frameworks. Key references were included in the references section.

2. Sectoral and Geographic Risk Mapping

We synthesized data from the ND-GAIN Index, World Bank Climate Change Knowledge Portal, International Monetary Fund (IMF) Climate Risk Assessment Tool, and sovereign climate vulnerability databases. Sectoral risk classifications were drawn from IEA transition assessments and McKinsey Global Institute's industry carbon footprint mappings.

3. Scenario Analysis Frameworks

The analysis builds on the NGFS Climate Scenarios (2022) and ECB stress test methodologies, incorporating high-, medium-, and orderly transition pathways. These scenarios reflect both physical and transition risks across varied temperature trajectories and policy regimes.

4. Case Studies and Market Data

We referenced real-world climate events and market responses, including:

- Swiss Re and Munich Re catastrophe loss databases
- Green bond issuance data from Climate Bonds Initiative
- Central bank regulatory disclosures and stress test results
- Industry climate pledges and investment portfolios

All figures and tables were constructed based on publicly available data, unless noted otherwise.

Appendix B: Glossary of Terms

Adaptation Finance: Capital allocated to increase resilience to the physical impacts of climate change.

Blended Finance: Structuring of finance that combines public and private capital, often to de-risk investments.

Climate Risk: Financial and economic risks resulting from the impacts of climate change or decarbonization.

Climate VaR (Value-at-Risk): A quantitative measure of potential financial loss under climate stress scenarios.

Green Bonds: Debt instruments used to finance environmentally beneficial projects.

ISSB: International Sustainability Standards Board, setting global climate disclosure standards.

Liability Risk: Risk of legal action due to failure to disclose, mitigate, or act on climate-related exposures.

Net-Zero: A commitment to reduce greenhouse gas emissions to zero, typically through decarbonization and offsets.

NGFS: Network for Greening the Financial System, a global group of central banks focused on climate risk.

Physical Risk: Risk from physical climate impacts such as floods, storms, droughts, or chronic heat.

Scenario Analysis: Risk modeling technique that evaluates potential outcomes under different climate pathways.

Stranded Assets: Assets that lose economic value due to climate-related changes, such as regulatory restrictions or demand collapse.

Sustainability-Linked Bonds: Bonds whose coupon or repayment terms depend on the issuer's climate or ESG performance.

Transition Risk: Risk arising from shifts in policy, regulation, technology, or market preferences in response to climate change.