

Global Risk and Resilience in Sustainable Climate Finance: Behavioral, Financial, and Governance Implications for Financial Institutions

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Climate change presents a paradox: regardless of ongoing debate about its causes or magnitude, the associated physical, transition, and liability risks pose tangible and increasingly material challenges for financial institutions (Carney, 2015; Peterson et al., 2023). This study examines climate-related financial risk through an integrated lens that combined extant literature, behavioral analysis, a detailed case study, and original empirical evidence drawn from a survey of ten executives and board members across seven U.S.-based credit unions. Survey findings revealed that most participants had not deliberately incorporated climate risk into strategic or risk-management processes; instead, attention to climate-related issues was often incidental or reactive. Several primary risk channels influencing institutional financial stability emerged: supply chain disruption, technology-related disruption (including business continuity and innovation-induced risk), and policy or regulatory transition risk. The article explores how these risks affect financial resilience, governance structures, socio-economic and geopolitical dynamics, and technology and sustainability strategies, with particular emphasis on managerial decision-making and board oversight (Laloties & Lamichhane, 2023; OECD, 2022). Long-tail risk and the skewness of climate-related disruptions are examined to illustrate the inadequacy of short-term planning horizons (Dietz et al., 2016). A detailed case study of California-based Meriwest Credit Union demonstrates how climate risk manifests operationally and strategically within a community-based financial institution. Grounded in prospect theory and enterprise risk management (ERM) (Freeman et al., 2010; Kahneman & Tversky, 1979; Paine, 2020), this study's primary focus was the behavioral (prospect theory) and enterprise risk management theoretical framework (ERM). The study suggests that deliberate, long-term, and behaviorally informed climate-risk management is essential for sustaining financial stability and organizational resilience in a low-carbon transition.

Climate change is rapidly emerging as one of the most consequential and contested issues confronting modern organizations and systems. While a broad international scientific consensus affirms that climate change is occurring and accelerating (Peterson et al., 2023), disagreement persists regarding its precise drivers, projected severity, and economic consequences. This divergence has produced a paradox for organizational leaders and policy-makers: even amid uncertainty or skepticism, climate-related disruptions increasingly impose hefty financial, operational, and strategic costs on institutions (Carney, 2015; Laloties & Lamichhane, 2023).

From a financial stability perspective, the practical question is no longer whether climate change is real, but whether organizations are adequately prepared to manage the risks that manifest irrespective of attribution debates. Financial institutions face exposure through asset valuation, credit quality, liquidity planning, insurance availability, infrastructure reliability, and regulatory compliance (Dafermos et al., 2018; OECD, 2021). Yet, existing evidence suggests that many institutions continue to treat climate risk as a peripheral or future concern rather than as a present strategic risk (Finance Watch, 2025).

This gap between risk manifestation and managerial attention is especially salient in mid-sized and community-based financial institutions. Unlike large global banks, such institutions often operate with constrained resources, regionally concentrated portfolios, and relatively short planning horizons (FDIC, 2023). As a result, climate risk is frequently addressed only indirectly—through disaster recovery planning, cybersecurity investments, or compliance initiatives—rather than through a deliberate, integrated strategy (FDIC, 2023; OECD, 2022).

Based on qualitative research findings and analysis, the authors advance a perspective that climate risk should be understood as a multidimensional financial risk with behavioral, organizational, and governance implications. Drawing on prior research in climate finance and risk management (Giglio et al., 2021; Laloties & Lamichhane, 2023) and supplemented by original survey and qualitative interview evidence from U.S. credit unions, the study reframes climate change not as an environmental abstraction but as a source of systemic financial exposure that necessitates intentional leadership focus and attention. Hence, this study contributes to the management literature by examining climate-risk decision making at the level of

boards and senior executives rather than at the firm level, an area that has received limited attention in prior management research.

Management Theories

The authors used Prospect theory and the ERM theoretical framework as the theoretical lens to understand the phenomena associated with the implications of climate risk on the behavioral, financial, and governance aspects of financial institutions. The goal was to analyze individual-level decision-making data gathered through this study's research, which could explain the phenomenon in far richer detail than in previous research.

Prospect theory posits that individuals or organizations evaluate their decision relative to a reference or an anchor rather than absolute outcomes. Additionally the theory posits that individuals or organizations demonstrate risk-averse behavior towards potential gains, while exhibiting risk seeking behavior when faced with potential losses of equivalent value. Viewing from the prospect theory lens, from the perspective of a financial institution board, the board members should strive to minimize emotional biases and make decisions pertaining to gains and losses through the prism of the institution's long-term financial stability.

Enterprise Risk Management (ERM) theoretical framework posits that in an organization the risk cannot be viewed in isolation but collectively within an integrated enterprise-wide framework where the cumulative impact of entire risk portfolio can be measured and mitigated in support of their strategic objectives. For an organization, ERM advocates risks should be viewed holistically from a governance perspective where the risks are systematically identified, measured, mitigated and continuously monitored on an on-going basis to achieve long-term strategic goals.

Climate Risk Typology: Physical, Transition, Liability, and Reputational Risk

Consistent with prior climate-finance frameworks, climate-related financial exposure has traditionally been categorized into physical risk, transition risk, and liability risk (Peterson et al, 2023; Task Force on Climate-related Financial Disclosures [TCFD], n.d.) Evidence from both the literature and the empirical findings of this study suggests that reputational risk also constitutes a fourth, distinct, and material category of climate-related risk.

Accordingly, this study adopts a four-part climate risk typology (see Appendix A): 1) Physical Risk, 2) Transition Risk, 3) Liability Risk, and 4) Reputational Risk. While analytically distinct, these risks are interdependent and often mutually reinforcing, with reputational risk acting as a key amplification mechanism through which physical, transition, and liability risks translate into financial instability. Appendix A illustrates the four primary climate-related risk categories examined in this study, as well as the second-order transmission channels through which climate risk propagates into financial instability.

Physical Risk

Physical climate risk refers to the direct financial and operational impacts arising from acute or chronic climate-related events, including extreme weather such as floods, hurricanes, wildfires, heatwaves, and storms that damage physical assets and disrupt operations (NOAA, 2022; White et al., 2023). Chronic risks develop more gradually and include rising temperatures, prolonged droughts, sea-level rise, and ecosystem degradation.

For financial institutions, physical risks translate into deteriorating collateral values, increased insurance costs or unavailability, higher default probabilities, business continuity disruptions, and localized liquidity stress (Harvard Law School Forum on Corporate Governance, 2025). Repeated exposure to physical hazards can undermine long-term asset viability and regional economic stability, particularly for institutions with geographically concentrated portfolios (USDA, Farm Service Agency, 2025).

Transition Risk

Transition risk arises from the economic, regulatory, technological, and/or market changes arising from shifts toward a lower-carbon economy (OECD, 2021; UNEP-FI, 2024). These risks include climate-related regulation, carbon pricing mechanisms, disclosure requirements, technological innovation, and evolving investor and consumer expectations.

From a financial standpoint, transition risks may lead to asset revaluations, stranded assets (investment losses due to premature obsolescence, for example), increased capital expenditure requirements, and uncertainty regarding return on investment (Dwortzan, 2022; Semieniuk & Holden, 2022). Institutions that fail to adapt may experience declining competitiveness and reputational harm, while premature or poorly executed transitions may also generate financial losses under uncertain policy conditions (Caldecott et al., 2013).

Liability Risk

Liability risk reflects the potential for legal claims or compensation demands arising from climate-related harm or misrepresentation. As disclosure regimes expand and stakeholder scrutiny intensifies, financial institutions face increasing exposure to litigation related to inadequate disclosure, greenwashing (deceptive marketing and false claims about climate-friendliness), or failure to manage known risks (Harvard Law School Forum on Corporate Governance, 2022).

Reputational Risk

Reputational risk refers to the erosion of stakeholder trust arising from perceived misalignment between an organization's actions and societal, regulatory, or market expectations regarding climate responsibility. Reputational damage may occur independently of legal liability and can materially affect financial performance, funding access, and long-term organizational viability. Reputational risk differs from liability risk in that it may materialize in

the absence of legal action and can propagate rapidly across stakeholder networks. In practice, reputational risk often acts as an amplifier, intensifying the financial consequences of physical, transition, and liability risks.

Integrating the Risk Framework

Physical, transition, liability, and reputational risks rarely occur in isolation. For example, physical events often trigger regulatory responses, disclosure scrutiny, and litigation, while transition policies can reshape asset values and amplify physical exposures (Lalotis & Lamichhane, 2023; Peterson et al., 2023;). Understanding climate risk through this integrated framework enables organizations to move beyond fragmented or reactive responses toward more holistic financial risk management.

Technology as a Transition Enabler

At the same time, technology plays a critical role in managing climate transition risk. Advances in data analytics, climate modeling, carbon accounting, and disclosure platforms enable organizations to measure and manage exposure more effectively (UNEP-FI, 2024). Technology also underpins market-based constructs such as emissions trading systems and carbon pricing corridors, which rely on accurate measurement and transparent reporting (Fuchs et al., 2024; World Bank, 2025).

However, adoption of such technologies requires investment, governance oversight, and organizational capability. Without deliberate strategy, technology initiatives risk remaining fragmented or underutilized, limiting their contribution to resilience.

Literature Review

Climate risk has been well studied in recent years and typically is found in finance and economics literature. Based on an extant literature search, the authors found very few published articles that could explain the phenomenon at the level of the individual decision maker rather than at the firm level. One article in the *Strategic Management Journal* considered management from the level of the firm (Huang et al., 2022).

As per Huang et al. (2022), “climate risk results in unfavorable corporate financing terms related to bank loans (higher interest paid, higher likelihood of being required to collateralize the loan, and greater number of covenant constraints)” (p.1). In the financial industry, climate risk has been recognized as the one of the key risks and needs to be included in the ERM framework in addition to the traditional credit and counterparty risk, market risk, operational risk, and liquidity risk, and strategic risk (Birindelli et al., 2022).

Muzuva & Muzuva (2024) observed that for banks to ensure long-term financial stability, integrating climate risk into their existing risk models, focusing on credit business strategies and evaluating the physical and transition risks, is of paramount importance to ensure long-term survival. Additionally, in the financial sector, regulators and policymakers play a vital role in supporting financial

stability by establishing regulatory frameworks that incentivize sustainable lending practices, mandate disclosures and promote transparency regarding climate risk exposure. A holistic approach that encompasses an integrated risk governance framework to address climate and environmental risks would be well-positioned to mitigate threats, comply with regulatory requirements, capture strategic opportunities, and achieve financial stability (Cucinelli et al., 2026).

Maturity in managing climate risk varies significantly across financial institutions. The banks with an integrated governance structure, board involvement, and a robust ERM model are best positioned to mitigate risks and leverage opportunities (Toma & Stefanelli, 2022).

Resource-Based View and Technological Capability

From a resource-based view (RBV), technological capability constitutes a strategic asset that can confer sustained competitive advantage when it is valuable, rare, inimitable, and well-integrated (Barney, 1991). Institutions that invest in integrated technology systems, skilled personnel, and adaptive processes are better positioned to manage climate-related disruptions across physical and transition dimensions (Campos et al., 2025).

Research Question

Question: To what extent are the top management teams and boards of directors aware of the ways in which climate risk impacts financial institutions’ financial resilience, reputation, governance structures, and socio-economic, geopolitical, and technology strategies?

Sub-question 1a: How does the effect of climate risk impact managerial decision-making, board oversight, and governance behavior?

Sub-question 1b: How can an organization’s Enterprise Risk Model (ERM) incorporate the long-tail risk and skewness of climate-related disruptions over a long-term planning horizon?

Survey: Method, Results and Findings

Survey Design and Methodology

To complement the conceptual and literature-based analysis, this study incorporated original empirical evidence drawn from a qualitative survey administered to ten senior executives and board members across seven U.S.-based credit unions in 2025. Participants included chief executive officers, chief financial officers, chief risk officers, chief information officers, and board directors. The institutions varied in asset size and geographic footprint, yet shared common characteristics typical of community-based financial institutions: regionally concentrated loan portfolios, relationship-based lending models, and strong reliance on local economic conditions.

The survey was semi-structured and exploratory in nature, designed to assess how climate-related risks are perceived, discussed, and operationalized within governance and management processes. Questions focused on risk identification, enterprise risk management integration,

board oversight, strategic planning horizons, capital allocation, and technology preparedness. Given the exploratory nature of the research and the limited prior empirical work on climate risk behavior within credit unions, a qualitative approach was deemed appropriate (Giglio et al., 2021; Laliotis & Lamichhane, 2023).

Survey Results and Discussion

Finding #1: Behavioral Finding—Incidental Rather Than Deliberate Attention

A clear and consistent finding across all respondents was that climate risk had not been deliberately or intentionally incorporated into institutional strategy or risk frameworks. Most executives and board members acknowledged that climate-related issues had entered organizational discussions “by accident,” often triggered by unrelated operational challenges such as wildfire insurance withdrawals, data center resiliency concerns, or vendor disruptions. One of the respondents stated, “Our board haven’t seen too much conversation about climate; we talk a lot about risk different types of risks but not much focus on climate risk.”

This behavioral pattern aligns with findings from behavioral finance and organizational decision-making research, which suggests that low-probability, high-impact risks often receive insufficient managerial attention or consideration until they materialize (Carney, 2015; Kahneman & Tversky, 1979). Climate risk, characterized by long time horizons and uncertain attribution, tends to fall outside conventional managerial attention cycles (Laliotis & Lamichhane, 2023).

All respondents explicitly noted that climate risk was not on the radar until physical events directly affected members or operations. Even then, responses were typically framed as short-term problem-solving rather than strategic risk reassessment. This emergent theme seemed to support prior research indicating that institutions often rely on reactive rather than anticipatory risk management when facing complex, non-linear threats (Dafermos et al., 2018; Finance Watch, 2025).

Implications for Financial Risk Identification

The incidental nature of climate-risk attention yields direct implications for financial risk identification. Without deliberate recognition, climate risk remains fragmented across traditional risk categories—credit risk, operational risk, compliance risk—without being assessed holistically. As a result, cumulative exposure may be underestimated.

Respondents commonly cited confidence in existing enterprise risk management (ERM) frameworks, yet few could articulate how climate-related risks were explicitly identified, measured, or stress-tested. One of the executives stated, “This is a good question, and I’m not sure if we are doing it.” This finding is consistent with supervisory concerns that have been expressed by financial regulators, who note that traditional risk frameworks may fail

to capture the compounding and long-tail characteristics of climate-related financial risk (FDIC, 2023; OECD, 2021).

Finding #2: Time Horizon Mismatch: Short-Term Planning vs. Long-Term Risk

A central theme emerging from the survey is the mismatch between institutional planning horizons and the temporal nature of climate risk. Most participating credit unions operate on capital and liquidity planning horizons of one to five years, consistent with regulatory expectations and industry norms (FDIC, 2023). Liquidity stress tests, interest rate risk models, and capital adequacy assessments are primarily designed to address near-term shocks.

While such frameworks are effective for managing conventional financial risks, they are poorly suited to addressing climate-related transition risks, which may unfold over 15–30 years (Carney, 2015; Laliotis & Lamichhane, 2023). Respondents acknowledged this gap but expressed uncertainty regarding how to operationalize long-term climate scenarios without clear regulatory mandates or industry benchmarks. One of the executives stated, “We really have not imbedded the climate risk in our strategic plan...many tactical initiatives are in place such as solar, EV charging, recycling etc.”

This horizon mismatch creates a structural blind spot: institutions may remain financially sound under short-term metrics while accumulating long-term vulnerability. Prior research has emphasized that delayed recognition of climate transition risk can lead to abrupt asset repricing and destabilizing financial shocks once thresholds are crossed (Dietz et al., 2016).

Finding #3: Limited Awareness of Long-Tail Risk and Skewness in Climate-Related Losses

Traditional financial risk models frequently assume that losses follow a normal (bell-shaped) probability distribution, in which extreme outcomes are rare and symmetrically distributed around the mean. Under such assumptions, risk management focuses on variance reduction and capital buffers calibrated to historically observed loss patterns. However, climate-influenced financial risk does not conform to these assumptions. Instead, both climate change-related physical and transition risk exhibit long-tail and skewed loss distributions, characterized by low-probability but high-impact outcomes (Laliotis & Lamichhane, 2023; Dietz et al., 2016). In such distributions, modest losses occur with relatively high probability, while catastrophic losses—though less frequent—extend far into the tail, posing existential threats to organizations.

The graphic in Appendix B illustrates this fundamental distinction. In a normal distribution, financial losses cluster around the mean, and extreme losses decline rapidly in probability. In contrast, the long-tail and skewed distribution associated with climate-related risk features an extended right tail, where the probability of extreme finan-

cial loss remains materially non-negligible. This asymmetry reflects the non-linear nature of climate disruption, in which thresholds, feedback loops, and compounding effects can abruptly amplify losses. Appendix B highlights why a reliance on backward-looking data and short-term averages systematically understates climate-related financial risk.

For financial institutions, the implications are profound. Long-tail climate risks challenge the adequacy of conventional stress testing, value-at-risk (VaR) models, and capital planning frameworks that are calibrated to normal distributions (Dafermos et al., 2018; Financial Stability Board, 2021). Institutions may appear resilient under standard models while remaining vulnerable to rare but catastrophic climate events.

The survey findings reinforced this concern. Executives and board members across the sampled credit unions demonstrated limited awareness of long-tail risk dynamics, often relying on historical loss experience as a proxy for future exposure. One of the respondents stated, “We have not incorporated climate risk in our ERM framework.” This behavioral tendency aligned with prospect theory, which, as mentioned earlier, suggests that decision-makers systematically do not even consider or are oblivious to low-probability, high-impact risks until they materialize (Kahneman & Tversky, 1979).

Accordingly, managing climate-related financial risk requires a paradigm shift from probability-based optimization toward resilience-oriented planning. Scenario-based stress testing, threshold analysis, and capital planning over extended horizons are essential to address the skewness and tail risk illustrated in Figure 2 (Lalotitis & Lamichhane, 2023; UNEP-FI, 2024).

Finding #4: Unprepared for Rapid Changes in Capital-Level Disclosures and Financial Vulnerability

Although none of the surveyed credit unions were currently subject to mandatory climate disclosure regimens, awareness of Scope 1, 2, and 3 greenhouse gas (GHG) reporting requirements is increasing (Harvard Law School Forum on Corporate Governance, 2025; Storebrand, n.d.). None of the respondents, however, could articulate how emissions data—particularly Scope 3 exposure embedded in loan portfolios and supply chains—might translate into financial risk.

Capital intensity of investments, defined as carbon emissions per unit of revenue or capital deployed, provides an important lens for assessing transition risk. Institutions with high carbon-intensity exposure may face asset revaluation, stranded assets, retrofitting costs, and higher capital requirements under evolving regulatory and market conditions (Campos et al., 2025; Semieniuk & Holden, 2022). The survey suggested that without deliberate integration of these metrics into financial planning, institutions risk being unprepared for rapid changes in disclosure expectations or market sentiment. One of the respondents stated, “We are working at the social responsibility level but not from a regulatory perspective.”

Finding #5: Limited Familiarity with Carbon Pricing, Volatility, and Investment Risk

Carbon pricing mechanisms—such as emissions trading systems (ETS)—introduce both opportunity and risk for organizations. Carbon price corridors, which establish floor and ceiling prices through regulatory intervention, are designed to reduce uncertainty and encourage long-term investment (UNEP-FI, 2024; World Bank, 2025). However, volatility within these corridors can generate unpredictable financial impacts, particularly for carbon-intensive borrowers and investment portfolios (Fuchs et al., 2024). Survey respondents expressed limited familiarity with carbon pricing dynamics, reflecting the early-stage engagement of most credit unions with transition risk markets. Nevertheless, the potential spillover effects—through borrower distress, collateral devaluation, or market instability—underscore the relevance of carbon pricing even for institutions not directly participating in emissions markets (OECD, 2021). Meriwest’s CFO stated that the credit union does not currently apply climate-adjusted ROI or internal carbon pricing in investment decisions, but recognizes the need to prepare for future regulatory requirements and plans to prioritize these enhancements.

Finding #6: Bounded Rationality in Climate-risk Management—Behavioral and Managerial Implications

From a behavioral perspective, the findings reveal a pattern of bounded rationality in climate-risk management. Executives and boards focus on risks that are salient, immediate, and historically familiar, while discounting abstract, long-term threats (Kahneman & Tversky, 1979). This behavior is reinforced by institutional incentives tied to short-term financial performance and regulatory compliance. One of the board members stated, “We have not talked about the financial risk related to climate.”

The results of this study and analysis suggest that improving climate-risk management is not solely a technical challenge but also a behavioral and governance challenge. Deliberate board engagement, clearer ownership of climate risk, and integration into ERM and capital planning are necessary to overcome cognitive and organizational barriers (OECD, 2022; World Economic Forum, 2019).

Finding #7: Inadequate Board Oversight of Climate-Related Financial Risk from Governance and Policy Perspective

Boards of directors occupy a central position in the governance of climate-related financial risk due to their fiduciary duties of care, loyalty, and compliance. These duties obligate directors to exercise informed judgment, oversee management, and safeguard the long-term financial viability of the organization (Sarraf, 2020; OECD, 2022). Climate change intersects directly with these responsibilities because it introduces material risks to asset values, credit quality, liquidity, operational continuity, and reputational standing (Lalotitis & Lamichhane, 2023; TCFD, n.d.).

Despite this stewardship, findings from the survey indicated that board-level engagement with climate risk remains limited and largely indirect. One of the board members mentioned that “Our board haven’t seen too much conversation about climate; we talk a lot about risk different types of risks but not much focus on climate risk.” Most board members did not identify climate risk as a standalone governance issue. Instead, climate-related considerations surfaced episodically—often through discussions on insurance availability, disaster recovery, cybersecurity resilience, or vendor risk. This pattern reflected what prior governance research has described as issue fragmentation, whereby cross-cutting risks lack clear ownership, and, therefore, fail to receive sustained oversight (OECD, 2022; World Economic Forum, 2019).

This governance gap may have significant implications. When climate risk is not explicitly recognized, boards may unintentionally breach their duty of care by failing to consider foreseeable, material long-term risks. Regulatory bodies and legal scholars increasingly argue that climate-related financial risk now falls squarely within the scope of fiduciary responsibility, particularly as evidence of financial materiality continues to accumulate (Harvard Law School Forum on Corporate Governance, 2025; Sarra, 2020).

Finding #8: Limited Integration of Climate Risk into Enterprise Risk Management

Enterprise Risk Management (ERM) provides a structured framework for identifying, assessing, and managing risks across the organization. ERM theory emphasizes interdependencies among risks and the importance of forward-looking analysis (COSO, 2017; Dafermos et al., 2018). However, the survey findings suggest that while ERM frameworks are widely implemented among credit unions, climate risk is rarely treated as an explicit risk category. One of the respondents stated, “We have a strong ERM framework...and at the board level we see a roll-up of top 10 risks and we do not see it (aka climate risk) in the list.”

Instead, climate-related exposures are embedded within traditional categories such as operational risk, credit risk, or compliance risk. Although this approach may capture certain short-term impacts, it may obscure the systemic and compounding nature of climate risk, particularly its long-tail characteristics (Dietz et al., 2016; Laliotis & Lamichhane 2023).

Scenario analysis and stress testing represent critical tools for addressing this limitation. Financial regulators increasingly emphasize scenario-based approaches to assess climate-related vulnerabilities under alternative future pathways (FDIC, 2023; UNEP-FI, 2024). Yet survey respondents reported limited use of climate scenarios, citing uncertainty about assumptions, lack of internal expertise, and absence of clear supervisory expectations. This finding is consistent with broader evidence that insti-

tutions often delay action on climate risk until regulatory requirements become explicit, reinforcing a reactive rather than anticipatory posture (Finance Watch, 2025; OECD, 2021).

Finding #9: Policy and Regulatory Uncertainty Leading to Financial Instability

Policy and regulatory developments constitute a core dimension of climate transition risk. Carbon pricing mechanisms, disclosure mandates, and prudent supervisory guidance continue to evolve across jurisdictions, creating uncertainty for financial institutions (UNEP-FI, 2024; World Bank, 2025). For community-based institutions such as credit unions, this uncertainty can discourage proactive investment in climate-risk capabilities, particularly in the absence of immediate compliance requirements. One of the respondents mentioned that “as a country we go through these times where it’s real important and then it is not... next thing you know that banks all fail and housing market crashes, not sure why we don’t learn from that.”

Survey participants expressed or implied a reluctance to move ahead of regulation, preferring to wait for clearer direction from primary regulators. While understandable from a short-term cost perspective, this approach heightens exposure to abrupt policy shifts that may require rapid, costly adjustments. Research on regulatory transition risk demonstrates that delayed adaptation can exacerbate asset revaluation shocks and undermine financial stability when regulatory thresholds are crossed (OECD, 2021; Semieniuk & Holden, 2022).

Finding #10: Climate Risk as a Catalyst for Systemic Disruption

Climate risk operates as a systemic catalyst, amplifying existing socio-economic and geopolitical vulnerabilities rather than acting as an isolated shock (Carney, 2015; Laliotis & Lamichhane, 2023). Physical climate events—such as hurricanes, floods, and wildfires—can destabilize communities, disrupt labor markets, and erode local economic foundations. These effects propagate through financial systems via increased credit risk, asset impairment, and liquidity stress (Peterson et al., 2023; World Bank, 2025). The CFO of Meriwest Credit Union explained that the credit union is directly impacted by natural disasters, with recent wildfires in Los Angeles affecting members’ homes and leading to insurance companies withdrawing from California, which in turn affects the credit union’s ability to lend and the quality of loan collateral.

Historical evidence underscores this dynamic. Major climate-related disasters have produced prolonged economic dislocation and fiscal strain on local governments, with cascading impacts on regional financial institutions (NOAA, 2022). Similarly, the survey findings suggested that credit unions also experience these effects acutely due to geographic concentration and close ties to local economies.

Finding #11: Limited Consideration of Migration Risk and Financial Stability

One of the most consequential socio-economic effects of climate change is population displacement. Communities facing repeated exposure to climate hazards must choose between rebuilding and relocation. Where insurance becomes unavailable or unaffordable and public support is insufficient, migration becomes a rational response (Peterson et al., 2023; World Bank, 2025), as was evidenced in the recent Maui fires.

From a financial perspective, climate-induced migration poses several risks. Out-migration reduces deposit bases, weakens loan demand, and impairs collateral values—particularly in housing markets. At the same time, receiving regions may experience rapid population growth, straining infrastructure and financial services capacity. Despite these implications, survey respondents reported no formal consideration of migration risk in strategic or financial planning. However, there was a mention by Meriwest's CFO of indirectly stemming out-migration such as addressing loan delinquencies of members affected by disasters by offering assistance such as payment deferrals or loan modifications, rather than issuing new unsecured loans.

This omission aligns with prior research indicating that socio-economic transmission channels of climate risk are often underestimated because they unfold gradually and indirectly (Dafermos et al., 2018; Lalotitis & Lamichhane, 2023).

Finding #12: Limited Visibility into Geopolitical and Supply Chain Dimensions

Climate risk also intersects with geopolitics through its impact on global supply chains, resource availability, and political stability. Disruptions to agricultural output, energy infrastructure, and critical mineral supply can intensify geopolitical tensions and economic volatility (OECD, 2022; World Bank, 2025). One of the board members stated, "Being in the southwest, water conservation (drought) is important, and the risk is real if we are lending to farms, golf courses, but not sure to what level we are thinking about it."

Financial institutions are exposed indirectly through lending relationships, investment portfolios, and member or customer dependence on affected sectors. The survey findings likewise indicated limited visibility into these second-order exposures, reinforcing the need for broader, systems-based risk assessment approaches.

Finding #13: Framing of Climate Risk as Operational or Technical Issue

Technology infrastructure is increasingly central to financial operations, making it a critical point of vulnerability to physical climate risk. Flooding, heatwaves, storms, and power disruptions can damage data centers, telecommunications networks, and energy supply systems, undermining business continuity (Canadian Climate Institute, 2024; NOAA, 2022). The CTO of Meriwest

Credit Union mentioned that the company is moving towards cloud computing to decentralize its needs, which helps negate some climate risks but increases operating expenses.

Survey respondents consistently cited business continuity and disaster recovery as key concerns, particularly given growing reliance on cloud computing and digital service delivery. However, these concerns were typically framed in technical or operational terms rather than explicitly linked to climate trends. This framing limits organizational capacity to anticipate compound risks, such as simultaneous physical disruption and cyber vulnerability during extreme events (Giglio et al., 2021).

Finding #14: Lack of Explicit Connectedness Between Cybersecurity Risk and Climate Stress

Climate-related disruptions can exacerbate cybersecurity risk by straining infrastructure, diverting resources, and creating operational blind spots. Empirical evidence from major cyber incidents demonstrates that organizational stress and system disruption increase susceptibility to cyberattacks (Boughton, 2025; IronNet Cybersecurity, 2021). The CTO of Meriwest Credit Union highlighted the importance of choosing major cloud vendors like AWS, Azure, and Google, ensuring replication and failover capabilities for resilience. The respondents acknowledged the success of this approach in terms of security and staff efficiency, but none of them called out connectivity between cybersecurity and climate risk. Although survey participants recognized cybersecurity as a top risk, few explicitly connected it to climate exposure. This separation reflects a broader tendency to silo technology risk, despite growing evidence that climate stress can amplify digital vulnerability (OECD, 2022).

Case Study: Meriwest Credit Union Method, Results, and Findings

Methodology and Rationale

Consistent with qualitative analysis in management and organizational studies, this case study adopted an exploratory, embedded design to examine how climate-related financial risk manifests within a mid-sized, community-based financial institution (Yin, 2018). The purpose of the case study was to supplement, expand upon, and validate the survey interviews conducted. Meriwest Credit Union was selected due to its geographic concentration in California—a region characterized by heightened exposure to wildfires, droughts, flooding, and insurance market instability—and because it reflects behavioral patterns identified in the broader survey sample.

The case draws on interviews with senior executives, board-level discussions, internal risk documentation, and observational data collected during the survey process. This triangulated approach enhances internal validity and allows for deeper insight into governance dynamics, managerial decision-making, and operational responses to climate-related disruptions (Eisenhardt, 1989).

Organizational Context and Climate Exposure

Meriwest Credit Union operates within a regional economy increasingly shaped by climate volatility. California's recurring wildfires, prolonged droughts, and extreme weather events pose material risks to residential and commercial real estate, infrastructure, and insurance markets (USDA, Farm Service Agency, 2025). These physical risks translate directly into financial exposure through collateral impairment, credit quality deterioration, and operational disruption.

As with many credit unions, Meriwest maintains a geographically concentrated loan portfolio, which amplifies sensitivity to localized climate shocks. Survey and interview evidence indicate that climate-related concerns first emerged operationally rather than strategically—most notably through wildfire-related insurance withdrawal and member hardship events. This mirrors the broader survey finding that climate risk tends to enter managerial awareness incidentally rather than through deliberate strategic planning (Finance Watch, 2025; Lalotitis & Lamichhane, 2023).

Strategy Alignment with a Low-Carbon Economy

Meriwest's engagement with the low-carbon transition has been selective and opportunistic. The credit union has historically offered green-oriented financial products, including solar energy loans and electric vehicle (EV) loan discounts, reflecting responsiveness to member demand and public policy incentives (OECD, 2021). However, these initiatives were not embedded within a formal climate strategy or transition-risk framework. As per Meriwest's CEO, "The Organization has not proactively communicated a strong climate or clean energy stance to the community or members, instead marketing solar and EV products on an ad hoc basis."

A pivotal episode involved a partnership with a solar-focused fintech provider intended to expand renewable energy lending. While strategically aligned with sustainability goals, the partnership introduced unanticipated counterparty and execution risk. When the fintech partner collapsed, several members were left with incomplete solar installations or unresolved financing obligations. Meriwest ultimately incurred additional costs to ensure project completion and protect member trust.

This experience illustrates a core transition-risk insight: innovation-driven decarbonization efforts can generate secondary operational and reputational risks if governance, due diligence, and contingency planning are insufficient (Dwortzan, 2022; Semieniuk & Holden, 2022). The case underscores the importance of integrating transition initiatives within broader risk governance structures rather than treating them as standalone product innovations.

Finding #15: Climate Risk Enters Organizational Awareness Through Operational Disruption Rather Than Strategic Foresight

Physical climate risk has exerted direct pressure on Meriwest's operations. Wildfire events have damaged member properties and destabilized the residential insur-

ance market, with insurers withdrawing coverage or significantly increasing premiums in high-risk zones (Harvard Law School Forum on Corporate Governance, 2025). As insured collateral is a prerequisite for mortgage lending, insurance unavailability constrained Meriwest's lending capacity and heightened portfolio concentration risk.

Operationally, climate-related disasters increased delinquency and default risk among affected members. Management responded through loan forbearance, payment deferrals, and individualized member assistance rather than expanding unsecured lending. While aligned with the credit union's cooperative mission, these actions required careful liquidity planning and capital management (FDIC, 2023). The Meriwest case study supports how physical climate risk extends beyond asset damage to influence lending strategy, balance sheet resilience, and long-term growth potential. Meriwest's CEO described that the organization previously considered climate-related risks, such as fire impacts on mortgage lending, at the enterprise level but later reclassified them as operational risks to be managed case by case.

Finding #16: Transition Initiatives Can Generate New Forms of Financial and Reputational Risk If Not Governed Holistically

Meriwest maintains a robust Enterprise Risk Management (ERM) framework and active Asset-Liability Committee (ALCO) process, traditionally focused on interest rate risk, liquidity risk, and capital adequacy. Climate risk, however, has not yet been formalized as a distinct risk category within these frameworks. Stress testing practices remain largely backward-looking, relying on historical data to model financial shocks. Management acknowledged that existing models do not adequately capture climate-driven long tail risks or compounding effects, consistent with concerns raised in the literature regarding the limitations of conventional risk models in the face of climate uncertainty (Dietz et al., 2016; Lalotitis & Lamichhane, 2023). Notably, Meriwest has begun using geographic exposure mapping to identify concentrations of climate-vulnerable collateral and to proactively engage affected members. This capability represents an important foundation for future climate stress testing and scenario analysis (UNEP-FI, 2024).

Finding #17: Physical Climate Risk Affects Lending Capacity, Insurance Markets, and Community Stability

At the governance level, Meriwest's board recognizes climate risk as increasingly relevant to members, lenders, and community stakeholders. However, board engagement has been constrained by limited climate-specific expertise and the absence of standardized reporting metrics. Climate-related issues are discussed episodically rather than systematically, reinforcing the pattern observed across the broader survey sample. As per Meriwest's CEO (and Board Director agreeing), "Neither the board nor the executive team has established accountability or performance metrics tied to climate risk or sustainability."

Board training initiatives are underway to improve literacy in climate-related financial risk, consistent with best-practice recommendations for climate governance (OECD, 2022; World Economic Forum, 2019). The case highlights a governance feedback loop identified in the survey: boards rely on management to elevate climate risk, while management hesitates to do so without explicit board direction. This dynamic underscores the importance of intentional governance structures, including clear ownership of climate risk and integration into board-level risk dashboards (TCFD, n.d.).

Finding #18: Governance and Behavioral Factors Significantly Shape Institutional Responses to Climate Risk

Meriwest has not adopted climate-adjusted return-on-investment (ROI) metrics or internal carbon pricing mechanisms. Nevertheless, management expressed awareness that future regulatory and market developments may necessitate such tools. Capital allocation decisions continue to prioritize balance sheet strength and operational resilience, reflecting cautious risk preferences.

From a behavioral standpoint, this caution aligns with prospect theory, which predicts loss aversion in the face of uncertain outcomes (Kahneman & Tversky, 1979). The Meriwest case illustrates how perceived downside risk associated with transition initiatives can outweigh potential long-term benefits, particularly in the absence of regulatory clarity or peer benchmarks.

Case Study Synthesis

The Meriwest Credit Union case reinforces several core themes of this study:

- Climate risk often enters organizational awareness through operational disruption rather than strategic foresight.
- Transition initiatives can generate new forms of financial and reputational risk if not governed holistically.
- Physical climate risk affects lending capacity, insurance markets, and community stability.
- Governance and behavioral factors significantly shape institutional responses to climate risk.

Theoretical Implications

This study contributes to management theory in two ways. First, it provides qualitative support for prospect theory by demonstrating that boards and executive teams systematically discount low-probability, long-horizon climate risks until those risks become operationally salient. Second, it extends the ERM framework by suggesting that climate risk should be treated as an explicit enterprise risk category rather than being dispersed across traditional operational, compliance, and credit-risk classifications.

The key themes that emerged from the study were:

- Importance of governance and behavioral factors, which significantly shape institutional responses to climate risk and align with to prospect theory. As per

the theory, organizations, as represented by the board members and top management, behave in a risk-averse manner and hence avoid necessary transformation due to fear of short-term losses. This is in line with the survey results and case study wherein the senior leadership is either oblivious or ill-prepared to make the required changes, which if not enacted could be potentially existential.

- ERM framework is an integrated governance and management approach to identify and mitigate risks in alignment with organizations strategy and risk appetite. The traditional ERM framework does not explicitly address climate risk; however, limited integration of climate risk into an organization's ERM not only underestimates the risk to the organization but also undermines the potential strategic benefits that can be accrued by integrating the risk into its fabric. A useful approach would be to incorporate climate risk into the ERM framework as an explicit integral risk within the existing framework.

Strategic Implications and Future Research

This study addressed the following research questions:

To what extent are the top management teams and board of directors aware of the ways in which climate risk impacts financial institutions' financial resilience, reputation, governance structures, and socio-economic, geopolitical, and technology strategies?

Sub-question 1a. How does the effect of climate risk impact managerial decision-making, board oversight, and governance behavior?

Sub-question 1b. How can an organization's Enterprise Risk Model (ERM) incorporate the long-tail risk and skewness of climate-related disruptions over a long-term planning horizon?

The survey and case study findings show that the top management teams and boards of directors have limited awareness of the ways in which climate risk impacts a firm's financial resilience, reputation, governance structures, and socio-economic, geopolitical, and technology strategies. Further, the findings of this study suggest that effective climate-risk management requires explicit recognition of long-tail risk, skewed loss distributions, and the extension of planning horizons well beyond traditional financial and credit cycles. Consistent with prior research, reliance on short-term historical data and conventional risk models systematically understates exposure to low-probability, high-impact climate events (Dietz et al., 2016; Laliotis & Lamichhane, 2023). Scenario-based stress testing offers a practical and actionable mechanism for evaluating organizational resilience under alternative climate futures. As illustrated conceptually in Appendix C, organizations could conceivably model two contrasting scenarios: one assuming limited or insignificant climate impacts and another assuming significant climate disruption. Comparing projected financial outcomes against organization-specific financial sustainability thresholds could enable institutions to better assess vulnerability,

inform capital planning decisions, and identify potential tipping points at which financial stability may become compromised (Carney, 2015).

Perhaps more importantly, Appendix C demonstrates that short-term financial stability does not guarantee long-term resilience. Under scenarios of significant climate change, financial risk may accelerate non-linearly and breach sustainability thresholds over extended horizons, even when near-term indicators remain favorable. This dynamic is particularly salient for financial institutions whose business models are geographically concentrated or heavily dependent on climate-exposed collateral and insurance markets. The Meriwest Credit Union case study reinforces these insights. While the organization has remained financially stable in the short term, the interaction of physical risk, transition risk, and reputational risk—including partner failure, insurance withdrawal, and heightened stakeholder expectations—illustrates how institutions may inadvertently progress toward unsustainable risk levels absent deliberate, forward-looking governance and planning.

From a governance and management perspective, the Appendix C framework encourages a shift away from attribution debates toward resilience-oriented decision-making. By focusing on whether an organization remains below critical sustainability thresholds under plausible climate scenarios, boards and executive teams can engage in more constructive, action-oriented discussions that integrate financial, operational, regulatory, and reputational considerations. Future research could build on this exploratory study by employing larger samples, quantitative modeling, and cross-sector comparisons. Additional work may be warranted to examine how board education, regulatory clarity, and behavioral interventions influence the integration of climate risk into enterprise risk management frameworks over time. Longitudinal studies may further clarify how early adoption of scenario-based planning affects institutional resilience and financial performance in the face of escalating climate-related disruptions.

Conclusion

Climate change presents a multidimensional challenge that transcends environmental concerns and directly implicates financial stability, organizational governance, socio-economic resilience, and geopolitical dynamics (Carney, 2015; Peterson et al., 2023). This study integrated theory, empirical survey evidence, and an in-depth case analysis to demonstrate that climate-related risks—particularly physical and transition risks—pose systemic threats across multiple time horizons. The survey of seven U.S.-based credit unions also revealed a critical behavioral insight: most executives and board members had not deliberately incorporated climate risk into strategic planning, with attention often arising incidentally rather than intentionally. The Meriwest Credit Union case study illustrates how this behavioral pattern manifests in practice, highlighting both vulnerabilities and opportunities for institutional learning.

From a theoretical perspective, these findings underscore the relevance of prospect theory, enterprise risk management in understanding climate-risk governance (Barney, 1991; Freeman et al., 2010; Paine, 2020). Organizations that proactively integrate climate risk into governance, financial planning, and operational decision-making will be better positioned to navigate uncertainty while preserving long-term stakeholder value. Ultimately, climate-risk management is proving to be no longer optional. It is becoming a strategic and fiduciary imperative that demands deliberate leadership, behavioral awareness, and long-term management commitment. The decisions institutions make today will shape not only their own resilience but also the economic and social systems upon which future generations depend.

References

- Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99–120. <https://doi.org/10.1177/014920639101700108>
- Birindelli, G., Bruno, M., Citterio, A., Fuso, U., & Magurano, A. (2022). Banks' governance and risk management frameworks: How to integrate ESG and climate risks. *Risk Management Magazine*, 17(1), 25–35. <https://arpi.unipi.it/bitstream/11568/1196379/1/RMM-2022-01-Excerpt-3.pdf>
- Boughton, B. (2025, April 23). *Top 20 breach impact analysis* (as of 2025). MacroPraxis Research Institute. <https://macropraxis.org/published-research/top-20-breach-impact-analysis-as-of-2025/>
- Caldecott, B., Howarth, N., & McSharry, P. (2013). *Stranded assets in agriculture: Protecting value from environment-related risks* (Report). Smith School of Enterprise and the Environment, University of Oxford. <https://www.smithschool.ox.ac.uk/sites/default/files/2022-03/stranded-assets-agriculture-report-final.pdf>
- Campos, G., de Silva, H., & Miller, M. (2025). *Carbon emissions, net-zero transition, and implications for equity portfolio risk* (Research Report). CFA Institute Research and Policy Center. <https://rpc.cfainstitute.org/research/reports/2025/carbon-emissions-net-zero-transition-implications-for-equity-portfolio-risk>
- Carney, M. (2015). *Breaking the tragedy of the horizon: Climate change and financial stability*. Bank of England. <https://www.bankofengland.co.uk/-/media/boe/files/speech/2015/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability.pdf>
- Canadian Climate Institute. (2024, July 23). *Fact sheet: Climate change and wildfires*. <https://climateinstitute.ca/news/fact-sheet-wildfires/>
- Committee of Sponsoring Organizations of the Treadway Commission (COSO). (2017). *Enterprise risk management—Integrating with strategy and performance*. Committee of Sponsoring Organizations of the Treadway Commission. <https://www.coso.org/enterprise-risk-management>
- Cucinelli, D., Nieri, L., & Piserà, S. (2026). Climate and environment risks and opportunities in the banking industry: The role of risk management. *International Journal of Finance & Economics*, 31(1), 1169–1185. <https://doi.org/10.1002/ijfe.3083>

- Dafermos, Y., Nikolaidi, M., & Galanis, G. (2018). Climate change, financial stability, and monetary policy. *Ecological Economics*, 152, 219–234. <https://doi.org/10.1016/j.ecolecon.2018.05.011>
- Dietz, S., Bowen, A., Dixon, C., & Gradwell, P. (2016). Climate value at risk of global financial assets. *Nature Climate Change*, 6(7), 676–679. <https://doi.org/10.1038/nclimate2972>
- Dwortzan, M. (2022, August 19). *Stranded assets could exact steep costs on fossil energy producers and investors*. MIT News. <https://news.mit.edu/2022/stranded-assets-could-exact-steep-costs-fossil-energy-producers-investors-0819>
- Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, 14(4), 532–550. <https://doi.org/10.5465/amr.1989.4308385>
- Federal Deposit Insurance Corporation (FDIC). (2023). *Principles for climate-related financial risk management for large financial institutions* [Joint principles]. <https://www.fdic.gov/news/inactive-financial-institution-letters/2023/principles-climate-related-financial-risk-management-large>
- Finance Watch. (2025). *A trillion dollars of climate risk: The case for a systemic risk buffer*. <https://www.finance-watch.org/policy-portal/sustainable-finance/report-a-trillion-dollars-of-climate-risk/>
- Financial Stability Board. (2021). *The availability of data with which to monitor and assess climate-related risks to financial stability*. <https://www.fsb.org/work-of-the-fsb/financial-innovation-and-structural-change/climate-related-risks/>
- Freeman, R. E., Harrison, J. S., Wicks, A. C., Parmar, B., & De Colle, S. (2010). *Stakeholder theory: The state of the art*. Cambridge University Press.
- Fuchs, M., Stroebe, J., & Terstegge, J. (2024). *Carbon VIX: Carbon price uncertainty and decarbonization investments*. National Bureau of Economic Research. <https://doi.org/10.3386/w32937>
- Giglio, S., Kelly, B., & Stroebe, J. (2021). Climate finance. *Annual Review of Financial Economics*, 13, 15–36. <https://doi.org/10.1146/annurev-financial-102620-103311>
- Harvard Law School Forum on Corporate Governance. (2022). *Guidance for engaging on climate risk governance*. <https://corpgov.law.harvard.edu/2022/02/22/guidance-for-engaging-on-climate-risk-governance-and-voting-on-directors/>
- Harvard Law School Forum on Corporate Governance. (2025, May 3). *Corporate climate disclosures and practices: Risk, emissions, and targets*. <https://corpgov.law.harvard.edu/2025/05/03/corporate-climate-disclosures-and-practices-risk-emissions-and-targets/>
- Huang, H. H., Kerstein, J., Wang, C., & Wu, F. (H.) (2022). Firm climate risk, risk management, and bank loan financing. *Strategic Management Journal*, 43(13), 2849–2880. <https://doi-org.ezp.lib.cwu.edu/10.1002/smj.3437>
- IronNet Cybersecurity. (2021, June 28). *New research finds the SolarWinds cyber attack cost affected companies in key sectors 11 % of total annual revenue on average* [Press release]. <https://www.ironnet.com/news/new-research-finds-the-solarwinds-cyber-attack-cost-affected-companies-in-key-sectors-11-of-total-annual-revenue-on-average/>
- Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2), 263–291. <https://doi.org/10.2307/1914185>
- Lalot, D., & Lamichhane, S. (2023). *Delays in climate transition can increase financial tail risks: A global lesson from a study in Mexico* (IMF Working Paper No. 2023/175). <https://doi.org/10.5089/9798400252433.001>
- Muzuva, M., Muzuva, D. (2024). The impact of climate change on banks loan portfolios and strategies for effective climate risk management. *International Journal of Research in Business and Social Science*, 13(6), 148–157. <https://doi.org/10.20525/ijrbs.v13i6.3510>
- National Oceanic and Atmospheric Administration (NOAA). (2022). *U.S. billion-dollar weather and climate disasters*. <https://www.noaa.gov>
- Organisation for Economic Co-operation and Development (OECD). (2021). *Financial markets and climate transition*. https://www.oecd.org/en/publications/financial-markets-and-climate-transition_759b71c1-en.html
- Organisation for Economic Co-operation and Development. (2022). *Climate change and corporate governance*. https://www.oecd.org/content/dam/oecd/en/publications/reports/2022/06/climate-change-and-corporate-governance_551e0831/272d85c3-en.pdf
- Paine, L. S. (2020). *Value shift: Why organizations must act responsibly*. Harvard Business Review Press.
- Peterson, C., Escrivá-Bou, A., Medellín-Azuara, J., & Cole, S.. (2023). *Water use in California's agriculture*. <https://www.ppic.org/publication/water-use-in-californias-agriculture/>
- Sarra, J. P. (2020). *From ideas to action: Governance paths to net zero*. Oxford University Press. <https://doi.org/10.1093/oso/9780198852308.001.0001>
- Semieniuk, G., & Holden, P. (2022). Fossil-fuel stranded asset risks held by individuals in OECD countries and non-OECD governments. *Nature Climate Change*, 12(6) 510–511. <https://doi.org/10.1038/s41558-022-01373-x>
- Storebrand. (n.d.). *Carbon footprinting and greenhouse gas (GHG) disclosure requirements: scope 1, scope 2, and scope 3 emissions*. <https://www.storebrand.com/sam/no/asset-management/sustainability/policies-and-governance/carbon-footprinting-of-investments/>
- Task Force on Climate-related Financial Disclosures. (n.d.). *Recommendations on governance and risk management*. <https://www.fsb-tcfd.org>
- Toma, P., & Stefanelli, V. (2022). What are the banks doing in managing climate risk? Empirical evidence from a position map. *Ecological Economics*, 200, Article 107530. <https://doi.org/10.1016/j.ecolecon.2022.107530>
- United Nations Environment Programme Finance Initiative. (2024, May 23). *New findings, same strong message: The Net-Zero Asset Owner Alliance updates its position on governmental carbon pricing*. <https://www.unepfi.org/industries/new-findings-same-strong-message-the-net-zero-asset-owner-alliance-updates-its-position-on-governmental-carbon-pricing/>
- USDA, Farm Service Agency. (2025, March 28). *USDA designates California as primary natural disaster areas for*

drought. <https://www.fsa.usda.gov/news-events/news/03-28-2025/usda-designates-california-primary-natural-disaster-areas-drought>

White, R. H., Anderson, S., Booth, J. F., Braich, G., Draeger, C., Fei, C., Harley, C. D. G., Henderson, S. B., Jakob, M., Lau, C.-A., Admasu, L. M., Narinesingh, V., Rodell, C., Roocroft, E., Weinberger, K. R., & West, G. (2023). The unprecedented Pacific Northwest heatwave of June 2021. *Nature Communications*, 14, Article 727. <https://doi.org/10.1038/s41467-023-36289-3>

World Bank. (2025). *State and trends of carbon pricing 2025*. <https://openknowledge.worldbank.org/entities/publication/e5f6e755-e6a6-4d2c-927a-23b5cc8a9b03>

World Economic Forum. (2019). *How to set up effective climate governance on corporate boards: Guiding principles and questions*. https://www3.weforum.org/docs/WEF_Creating_effective_climate_governance_on_corporate_boards.pdf

Yin, R. K. (2018). *Case study research and applications* (6th ed.). Sage.

Appendix A

Climate Risk Typology: Physical, Transition, Liability, and Reputational Risk

Climate-related financial risk can be categorized into four primary types: physical risk, transition risk, liability risk, and reputational risk. Physical risk arises from natural disasters and can generate second order (derived) risks, including supply chain disruptions and technological disruptions. Transition risk stems from policy, regulatory, and technological changes spurred by shifting to a low-carbon economy, including disclosure requirements and emissions trading systems (ETS). Liability risk reflects legal and regulatory exposure related to climate-related harm. Reputational risk operates as a distinct and cross-cutting risk that can materialize independently or amplify the financial impact of physical, transition, and liability risks through loss of stakeholder trust and organizational legitimacy.

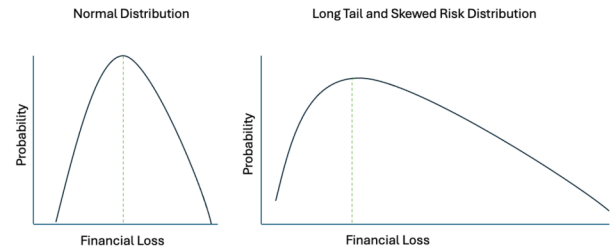


Appendix B

Normal Distribution Versus Long Tailed Skewed Risk Distribution

The left panel in the Figure illustrates a traditional normal distribution of financial loss, in which extreme outcomes are rare and symmetrically distributed around the mean. The right panel illustrates a long-tail and skewed distribution characteristic of climate-related financial risk, where the probability of extreme financial loss remains materially significant. Such distributions reflect the non-linear, compounding nature of

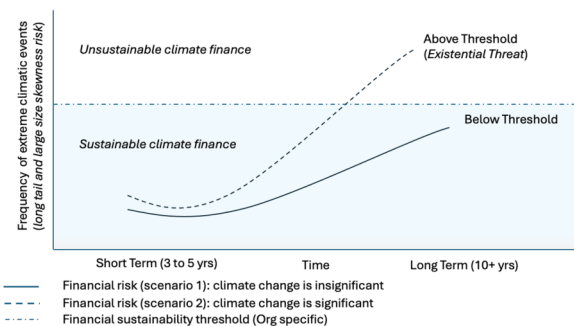
climate-related physical and transition risks and underscore the limitations of conventional risk models based on historical averages.



Appendix C

Scenario-Based Stress Testing Framework Illustrating the Impact of Climate Change on Financial Sustainability

Scenario 1 assumes insignificant climate change impacts, maintaining financial stability. Scenario 2 assumes significant climate change impacts, leading to a breach of financial sustainability thresholds.



Appendix D

Semi-Structured Guides Used for Credit Union Executive Interviews: Guide used for CTOs

Top 10 Climate Financial Risk Questions

1. Technology Alignment

Are our technology and infrastructure strategies aligned with the company's decarbonization and net-zero goals?

2. Financial Viability

How do climate-adjusted ROI and total cost of ownership (TCO) influence our technology investment decisions?

3. Energy Dependence

What is our plan to transition data centers and compute power towards cleaner, more reliable energy sources?

4. Operational Resilience

How resilient are our data centers, networks, and digital supply chains to extreme weather and energy disruptions?

5. Carbon Data & Measurement

Do we have accurate, auditable data on the carbon footprint of our IT operations and vendor ecosystem?

6. Regulatory Compliance

Are our technology-related emissions and disclosures compliant with global reporting standards (e.g., NCUA, TCFD, ISSB, SEC)?

7. Innovation & R&D Focus

Are we investing in emerging technologies (AI, edge, green cloud, hydrogen, carbon capture) that reduce emissions and improve ROI?

8. Vendor & Supply Chain Risk

Are our hardware, cloud, and software vendors aligned with our sustainability and resilience objectives?

9. Workforce & Ethics

How are we addressing the ethical, workforce, and retraining implications of the climate and digital transition?

10. Governance & Oversight

How frequently does the CTO organization assess climate-related technology risks with Finance, Risk, and Sustainability leaders?

Guide Used for Board Members**Top 10 Board Climate Finance Risk & Oversight Questions**

This one-page question bank is designed for Board Members to evaluate governance oversight, strategic alignment, and accountability regarding climate-related financial risks and opportunities.

1. Strategic Alignment & Oversight

How effectively is the board overseeing the company's alignment with national and global climate transition goals (e.g., Net Zero 2050)?

2. Risk Governance & Accountability

Has the board clearly defined its role and accountability in overseeing climate-related financial risks and sustainability performance?

3. Climate Competence & Education

Does the board collectively possess the knowledge and expertise needed to understand climate-related financial risks, or is further training required?

4. Integration into Enterprise Risk Management (ERM)

Is climate risk integrated into the company's Enterprise Risk Management (ERM) framework, and does the board regularly review scenario analyses or stress-testing results?

5. Financial Impact & Valuation Oversight

How does the board ensure that climate risks are reflected in asset valuations, impairment testing, and capital allocation decisions?

6. Disclosure & Transparency

Are the company's climate-related disclosures complete, auditable, and compliant with NCUA or any related regulatory requirements?

7. Executive Incentives & Accountability

Are executive compensation and performance evaluations linked to measurable climate or sustainability targets?

8. Stakeholder & Investor Engagement

How is the board engaging with members, regulators, and stakeholders on climate finance, transparency, and transition strategy?

9. Long-Term Resilience & Strategy

Does the board regularly review the company's resilience under various climate transition and physical risk scenarios?

10. Ethical Leadership & Fiduciary Duty

How does the board balance fiduciary duties to members with its ethical and societal responsibilities in guiding the company's climate strategy?

Guide Used for CEOs**Top 10 CEO Climate Finance Risk & Strategy Questions**

This one-page question bank is designed for Chief Executive Officers (CEOs) to evaluate enterprise-wide strategy, resilience, and leadership on climate-related financial risks and opportunities.

1. Strategic Alignment & Enterprise Vision

How well is our corporate strategy aligned with the global transition to a low-carbon economy and the expectations of members, regulators, and investors (lenders)?

2. Climate Risk Integration

Have we embedded climate-related financial risks—both transition and physical—into enterprise risk management, strategic planning, and capital allocation decisions?

3. Financial Resilience & Business Model Adaptation

How resilient is our current business model to carbon pricing, regulatory tightening, and technological disruption, and what diversification strategies are in place?

4. Investor Confidence & Market Positioning

How are we communicating our climate transition plan to NCUA, members, lenders, and communities to maintain confidence and access to capital?

5. Governance & Board Oversight

Does our board have clear accountability for climate risk and sustainability performance, and does the executive team have defined roles and metrics tied to it?

6. Stakeholder & Societal Expectations

How are we balancing members' returns with societal and environmental expectations—ensuring a 'just transition' for employees, suppliers, and communities?

7. Disclosure & Transparency

Are our climate and sustainability disclosures comprehensive, comparable, and auditable, in line with NCUA and other credit union regulatory standards?

8. Innovation & Growth Opportunities

What portion of our capital investments e.g., technology, innovation etc. are directed toward low-carbon innovation, or green product lines that can drive future growth?

9. Cross-Functional Accountability

How effectively do Finance, Technology, Operations, and Sustainability functions collaborate to measure, mitigate, and report climate-related risks and performance?

10. Long-Term Value & Legacy

What is our long-term ambition—not just for compliance, but for value creation, resilience, and leadership in a sustainable and net-zero economy?

Guide Used for CFOs**Top 10 CFO Climate Finance Risk & Resilience Questions**

This one-page question bank is designed for Chief Financial Officers (CFOs) to assess financial exposure, resilience, and governance readiness in response to climate-related risks.

1. Financial Exposure & Transition Risk

How exposed is our balance sheet and investment portfolio to transition risks such as carbon pricing, regulation, or stranded assets?

2. Cost of Capital and Funding Strategy

How does climate risk influence our cost of capital, credit ratings, and access to sustainable financing instruments (e.g., green bonds, ESG-linked loans)?

3. Capital Allocation & ROI

Are we applying climate-adjusted ROI or NPV metrics when evaluating major capital expenditures and investment decisions?

4. Scenario Analysis & Stress Testing

Do we run climate scenario analyses or NGFS-aligned stress tests to assess financial resilience under 1.5°C, 2°C, or disorderly transition scenarios?

5. Disclosure & Compliance Readiness

Are our climate-related financial disclosures compliant with NCUA standards, and can they withstand external audit assurance?

6. Liquidity, Insurance & Contingency Planning

How are physical climate risks—such as floods, wildfires, or energy disruptions—reflected in our liquidity buffers, insurance coverage, and contingency funding?

7. Carbon Pricing & Internal Valuation

Do we use an internal carbon price in forecasting, budgeting, and valuation models to account for future regulatory costs?

8. Investor & Credit Market Expectations

How are members and lender expectations regarding climate risk disclosure and decarbonization targets influencing our financing strategy?

9. Governance & Cross-Functional Coordination

How effectively do Finance, Risk, Sustainability, and Technology functions coordinate on climate risk governance, data accuracy, and reporting?

10. Long-Term Resilience & Value Creation

What is our plan to ensure financial resilience and enterprise value preservation as we transition to a low-carbon economy over the next 5–10 years?

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