CLIMATE-INDUCED CREDIT RISKS AND THE FINANCIAL STABILITY OF COMMERCIAL BANKS IN KENYA

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ABSTRACT

Commercial banks remain central to credit intermediation, savings mobilization, and payment systems, making their stability essential for sustained economic growth. In Kenya, this stability has been increasingly tested by climate variability heighten financial risks. Sector-wide resilience, measured by the average Z-score, fell sharply from above 100 in 2010 to about 18 in 2013, before settling in a range of 26 to 40 between 2021 and 2024. Although climate shocks are now recognized as key threats to banking systems, empirical evidence on their precise impact, particularly through mediation and moderation channels, has been mixed. This study examined how climate-induced credit risk affect the financial stability of commercial banks in Kenya. The analysis was anchored on Credit Risk Theory and Financial Sustainability Theory. A census of all 39 commercial banks was undertaken using secondary data from audited bank statements, Central Bank of Kenya supervision reports, macroeconomic bulletins, and climate-event records covering the period 2010–2024. Financial stability was proxied by the Z-score, while earnings volatility was measured as the rolling standard deviation of return on assets. Fixed effects panel regressions confirmed that climate-induced credit risk ($p<0.001$) significantly reduced financial stability. The study concludes that climate-induced credit risk exerts a structurally destabilizing influence on the banking system, as sustained exposure undermines loan portfolio quality and heightens systemic fragility. It is recommended that the Central Bank of Kenya and the National Treasury revise prudential guidelines to require integration of climate-adjusted credit default probabilities into capital adequacy computations and credit portfolio risk weighting.

Keywords: Climate-Induced Credit Risk, Climate Shock Dummy, Financial Stability, Non-performing Loans

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INTRODUCTION

The significance of climate-induced credit risk lies in its potential to impair asset quality and undermine the stability of financial institutions. As weather-related disasters become more frequent and severe, loan defaults are expected to rise—particularly among borrowers in vulnerable rural and informal sectors. According to the Central Bank of Kenya (CBK, 2021), nearly one-third of Kenyan banks' loan exposures are linked to climate-sensitive industries, highlighting the magnitude of the risk. Inadequate borrower insurance, lack of climate adaptation infrastructure, and limited access to government support compound the problem, making credit losses more persistent. Regional institutions such as the African Development Bank (AfDB, 2023) have also emphasized the need for banks to reassess their credit risk models to incorporate environmental and climate-related dimensions as part of sustainable financial practices.

A wide range of metrics has traditionally been used to measure credit risk, including default rates, loan-loss provisions, risk-weighted asset ratios, and credit spreads (Basel Committee on Banking Supervision [BCBS], 2019; Jokipii & Milne, 2011; Tan & Anchor, 2017). While these indicators remain essential for regulatory and portfolio risk assessments, they are largely backward-looking and may not reflect exogenous or systemic threats such as climate change. In particular, they often fail to capture the environmental triggers that can simultaneously impair entire sectors, especially in developing economies where sectoral exposures are concentrated (NGFS, 2023; IMF, 2023).

This study employed a more dynamic and context-sensitive metric: the interaction between the Non-Performing Loan (NPL) ratio and a climate shock dummy variable. This modeling strategy aligns with emerging practices in climate-finance econometrics, where interaction terms are increasingly used to capture exogenous shock amplification (Battiston, Mandel, Monasterolo, Schütze, & Visentin, 2017; Dunz, Mazzocchetti, & Monasterolo, 2021). In the Kenyan context, this approach found empirical support in recent studies linking weather extremes to financial distress within bank portfolios (Maureen, Omollo, & Obonyo, 2023; CBK, 2025). The advantage of this specification lies in its ability to attribute changes in loan performance more precisely to climate events, improving the diagnostic accuracy of climate-related credit risk assessments.

To operationalize this interaction, the study identified and classified major climate events in Kenya from 2010 to 2024 as country-wide severe events. These events informed the construction of the binary climate dummy variable (CICR_Country Wide = 1), applied consistently across both the credit risk and liquidity risk models. The classification was grounded on a set of robust criteria, including official national emergency declarations by institutions such as the National Drought Management Authority (NDMA), the Central Bank of Kenya (CBK), and the Kenya Red Cross; the extent of multi-county or national-scale disruption to key sectors such as agriculture and infrastructure; documented regulatory or humanitarian interventions at national or international levels (e.g., IMF, World Bank, or UN OCHA); and cross-verification with authoritative disaster registries such as EM-DAT and climate advisory reports from ICPAC. This approach ensured that the dummy variable captured macro-financial relevance, avoiding the dilution effects that would arise from oversaturation with localized or minor incidents. The full list of events used in constructing this variable is provided in Appendix III.

Financial Stability of Commercial Banks in Kenya

In Kenya, commercial banks play a dominant role in financial intermediation, contributing over 90% of total financial system assets (CBK, 2023). Their stability underpins investment, employment, and fiscal operations. When stable, banks channel savings into productive sectors, sustain credit supply, and support monetary policy transmission. However, instability can lead to credit rationing, erosion of trust, and broader macroeconomic risks. Recent structural shifts—including climate-induced credit losses, policy-driven reallocation of portfolios, and market volatility have raised concerns about the long-term resilience of the sector (Maureen, Omollo, & Obonyo, 2023; Gondwe et al., 2024).

Financial stability can be assessed using various indicators. Commonly used measures include profitability ratios such as Return on Assets (ROA) and Return on Equity (ROE); asset quality indicators like the Non-Performing Loan (NPL) ratio; capital adequacy metrics such as the Capital Adequacy Ratio (CAR); and liquidity indicators such as the Liquidity Coverage Ratio (LCR) and Loans-to-Deposits Ratio (LDR). While useful, these measures often reflect only partial dimensions of institutional health and may not adequately capture vulnerability under uncertain, forward-looking scenarios (FSB, 2023; CBK, 2025).

To overcome this limitation, this study adopts the **Z-score** as a composite and forward-looking measure of bank-level financial stability. The Z-score is calculated as the sum of Return on Assets (ROA) and the Equity-to-Assets ratio divided by the standard deviation of ROA. This formulation estimates the number of standard deviations a bank's returns would need to fall before capital is exhausted, offering a measure of distance to default. A higher Z-score indicates greater resilience, while a lower score reflects elevated insolvency risk (Moreno et al., 2022). The Z-score is empirically supported as a reliable indicator of bank fragility. Gondwe et al. (2024) demonstrate that banks in Sub-Saharan Africa with declining Z-scores are more vulnerable to macro-financial and environmental shocks. Similarly, Maureen et al. (2023) found that Kenyan banks exposed to climate-sensitive sectors showed persistently lower Z-scores during periods of prolonged drought. Unlike single-dimension indicators, the Z-score captures not only profitability, but also capital adequacy and earnings volatility making it particularly relevant in environments characterized by systemic and climate-related risks.

Figure 1.1 below presents the estimated Z-score trend of Kenyan commercial banks from 2010 to 2025, using a benchmark vulnerability threshold of Z = 30 to evaluate the sector's financial resilience. This benchmark, grounded in established financial soundness literature, has been widely adopted by scholars and policy institutions to distinguish between stable and vulnerable banking systems (Čihák & Schaeck, 2019; Ozili, 2021; Barrell et al., 2020). A Z-score above 30 typically indicates a relatively sound financial position, while scores below this mark suggest increased susceptibility to shocks or systemic stress.

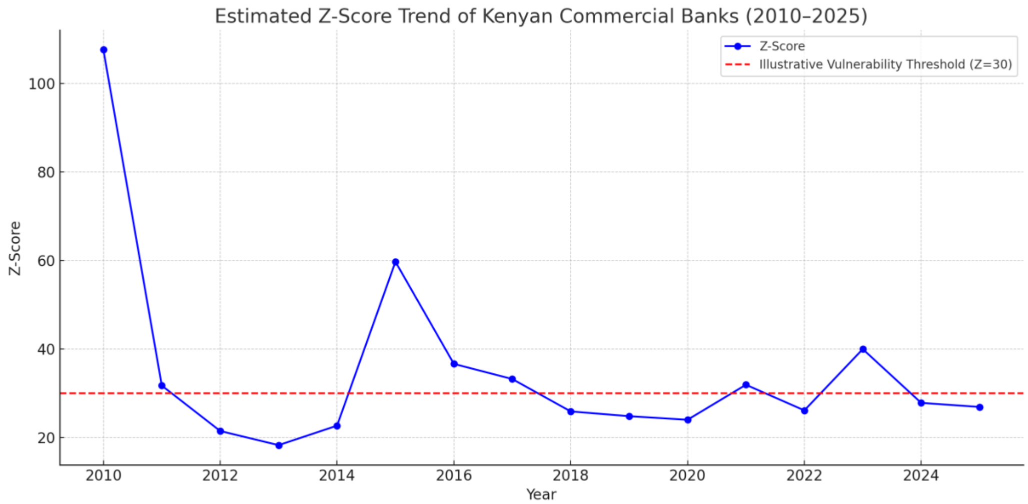

Figure 1 Estimated Z-score trend of Kenyan commercial banks from 2010 to 2025

Figure 1 above shows the estimated Z-score trend of Kenyan commercial banks from 2010 to 2025, benchmarked against a recognized vulnerability threshold of Z = 30. The Z-score a widely used measure of bank stability captures the number of standard deviations a bank's return on assets must fall to exhaust its equity (Čihák & Schaeck, 2019). At the start of the period, in 2010, the Z-score stands exceptionally high at over 100, reflecting strong profitability, adequate capital buffers, and minimal earnings volatility. However, from 2011 onward, the Z-score rapidly declines, reaching a low of approximately 18 in 2013, signaling rising institutional fragility.

A notable rebound in 2015 (approaching 60) suggests temporary resilience, followed by a moderate but sustained descent through 2020. Between 2021 and 2025, Z-scores hover narrowly around the vulnerability threshold ranging between 26 and 40 indicating a period of precarious balance between recovery and latent instability. According to Barrell et al. (2020), banks with Z-scores below 30 are generally more vulnerable to shocks, and these values suggest that the Kenyan banking sector may have faced tightening resilience margins in the wake of external stressors.

The downward trajectory and subdued recovery of Z-scores in later years raise significant concerns regarding the sector's exposure to systemic risks, especially those emanating from climate-related disruptions. The post-2015 moderation in stability—seen in values persistently near the threshold could reflect mounting exposures to risks associated with droughts, floods, and irregular rainfall patterns, all of which disrupt credit quality, impair asset returns, and strain liquidity. These dynamics align with the growing literature on climate-induced financial fragility, where profitability and risk buffers are eroded by environmental stressors (Ozili, 2021). Moreover, the failure of Z-scores to return to earlier robust levels suggests that climate-related risks may have more durable, compounding effects on financial resilience than previously assumed. The figure motivates the subsequent empirical investigation of whether climate shocks through credit impairments, market repricing, or liquidity stress materially weakened the structural soundness of Kenya's banking system.

Commercial Banks in Kenya

As of June 2024, the Central Bank of Kenya had licensed a total of 39 commercial banks and 1 mortgage finance institution (MFI). While both categories operate under CBK regulation, this study exclusively focuses on commercial banks, excluding the lone MFI due to its specialized portfolio structure and limited exposure to climate-sensitive sectors. Commercial banks, by contrast, are characterized by more diversified loan books spanning agriculture, construction, energy, and manufacturing sectors that are acutely vulnerable to physical climate shocks. Additionally, commercial banks engage in intermediation activities that directly influence liquidity creation, credit expansion, and asset reallocation, making them empirically suitable for assessing climate-related financial risks and their implications for systemic stability.

The justification for focusing on these 39 commercial banks is further reinforced by their dominant role in Kenya's financial system, where they collectively account for over 90% of total banking assets (CBK, 2023). This concentration underscores their systemic importance: any material climate-induced disruption within these institutions has direct implications for credit allocation, monetary policy transmission, and broader macroeconomic resilience. Moreover, commercial banks serve both urban and rural markets, bridging the formal and informal sectors and exposing their balance sheets to climate-sensitive borrower groups. Their asset concentration and network penetration thus position them as the most appropriate empirical units for investigating the nexus between climate induced credit risk and financial fragility in Kenya's context.

Longitudinal analysis of the sector's Z-score trends a composite measure of bank stability demonstrates a dynamic vulnerability profile over the period 2010 to 2025. At the start of the decade, Z-scores exceeded 100, reflecting strong capital buffers, high profitability, and minimal earnings volatility. However, from 2011 to 2013, these scores plummeted to lows of 18, indicating severe erosion in financial resilience. A temporary recovery occurred around 2015, with Z-scores nearing 60, but the stability gains were not sustained. From 2021 to 2025, Z-scores hover in the 26 to 40 range, fluctuating near the widely accepted vulnerability threshold of Z = 30. This persistent decline aligns temporally with periods of recurrent droughts and floods, suggesting that climate-related financial pressures may be contributing to weakening stability margins across the sector.

Beyond balance sheet resilience, commercial banks also play a pivotal role in Kenya's real economy. According to recent data from the Kenya National Bureau of Statistics (KNBS, 2023), the financial and insurance sector contributed approximately 9.1% of the country's Gross Domestic Product (GDP). Within this, commercial banks account for the largest share through credit intermediation, trade finance, and capital market facilitation. Their extensive linkage with key sectors particularly those vulnerable to climate shocks such as agriculture, construction, and real estate means that banking sector stability is inextricably tied to Kenya's climate adaptation and economic resilience agenda. As such, studying the evolving climate-financial risk interface within this sector is not only analytically appropriate but also of critical policy relevance.

Statement of the Problem

Empirical indicators highlight a troubling decline in bank stability over the period 2010 to 2025, as reflected in Z-score trends. In 2010, the average Z-score exceeded 100, signaling strong resilience. However, between 2011 and 2013, scores fell drastically to 18, suggesting severe fragility. A brief recovery around 2015 brought scores to approximately 60, but from 2021 to 2025, Z-scores consistently range between 26 and 40, hovering near the vulnerability threshold of Z = 30. This downward trend aligns with increasing climate shocks and the initial implementation of climate policies, indicating potential structural erosion in bank stability. The persistence of these low scores underscores the need to empirically assess whether and through which channels climate-related financial risks are undermining the resilience of Kenya's commercial banking sector.

Although climate finance remains an emerging field, a growing body of research has explored the influence of climate-induced credit risks on banking systems. These contributions have generated important insights, yet significant gaps persist. The first is conceptual. Much of the existing literature examines climate-induced credits risk without recognizing their combined influence on bank stability. For instance, Odongo, Misati, Kageha, and Wamalwa (2022) in Kenya linked climate variability to non-performing loans but did not incorporate the mediating effects of earnings volatility or the moderating role of gross domestic product. Similarly, Battiston, Mandel, Monasterolo, Schütze, and Visentin (2017) in OECD countries analyzed transition-related asset devaluations without considering the interaction between such risks, internal income stability, and macroeconomic resilience in emerging economies. This study addressed the conceptual limitation by ascertaining the connection between climate induced credit risk and financial fragility in Kenya.

Building on this conceptual gap, a second limitation is methodological. Many prior studies rely on descriptive profiling or aggregated indicators, which mask differences across institutions and over time. The Climate Risk Vulnerability Assessment (2022) in Kenya mapped sectoral exposures to climate risks but did not employ econometric modelling, validated event-based measures of climate shocks, or multidimensional stability indicators. Comparable limitations appear in Djalilov, Ólafsson, and Ponomareva (2022) in Eastern Europe and Armas, Cevik, and Doan (2023) in Southeast Asia, where mediating and moderating mechanisms were absent. Even within Africa, studies such as Mutuku and Wambua (2024) and Kirui, Rop, and Mutai (2023) did not apply longitudinal causal frameworks capable of capturing the dynamic effects of climate events. This study addressed these methodological weaknesses by estimating panel regression models with mediation and moderation specifications over a fifteen-year period, using validated climate-event variables and the Z-score to quantify multi-year impacts on bank stability.

Extending beyond methodological issues, the third gap is contextual. Much of the evidence comes from advanced economies with strong regulatory systems and comprehensive climate data, limiting its relevance to Kenya's semi-arid environment and evolving regulatory framework. For instance, Delis, de Greiff, and Ongena (2021) in Europe and Wang, Li, and Zhang (2024) in China assessed climate policy effects under markedly different institutional and climatic conditions. Within Africa, Mbotho and Zhou (2025) in South Africa and Dikgang, Nhamo, and Musvoto (2020) on anticipated carbon tax impacts did not integrate physical and transition risks into a unified analytical framework. This study directly addresses this contextual shortcoming by situating its analysis within Kenya's documented climate events, aligning with regulatory milestones such as the Central Bank of Kenya's 2021 Climate Risk Guidelines and the 2025 Green Finance Taxonomy, and using bank-level data to generate findings that are both scientifically robust and policy-relevant.

Study Objectives

The objective of this study was to examine the effect of climate-induced credit risks on the financial stability of commercial banks in Kenya

Research Hypotheses

H_{01}: Climate-induced credit risks have no significant effect on the financial stability of commercial banks in Kenya.

Theoretical Review

Credit Risk Theory

The Credit Risk Theory was advanced by Stiglitz and Weiss (1981) to explain how asymmetric information influences credit market outcomes, particularly the occurrence of credit rationing. According to the theory, lenders cannot fully differentiate between high-risk and low-risk borrowers, leading them to restrict credit supply rather than raise interest rates indiscriminately. This response stems from the fear that higher interest rates may disproportionately attract riskier borrowers and discourage low-risk ones. Within the realm of climate finance, the theory is increasingly relevant as banks face heightened credit exposure in sectors vulnerable to climate-related shocks and uncertainties.

The theory is anchored on several assumptions. Firstly, it assumes imperfect and asymmetric information between borrowers and lenders, where borrowers have superior knowledge about their default probabilities. Secondly, it presumes rational lender behavior focused on maximizing expected returns while minimizing exposure to risk. Thirdly, the theory posits that beyond a certain point, increasing interest rates not only fails to ration credit but also induces adverse selection and moral hazard. Fourthly, it assumes that credit markets may not always clear through price mechanisms, resulting in creditworthy firms being excluded from borrowing (Stiglitz & Weiss, 1981; Freixas & Rochet, 2008; Pagano & Jappelli, 1993). Lastly, it relies on the idea that lenders use non-price rationing mechanisms to allocate credit amidst risk and uncertainty.

Empirical applications of the theory have increasingly explored its relevance to climate-induced financial risks. Kling, Volz, Murinde, and Ayas (2021) analyzed European banks and found that credit portfolios exposed to carbon-intensive sectors faced elevated default risks.

Battiston, Mandel, Monasterolo, Schütze, and Visentin (2017) demonstrated that financial institutions globally were vulnerable to cascading credit losses due to carbon policy shocks affecting interconnected borrowers. Kanga and Njuguna (2023) provided local evidence in Kenya, showing that prolonged droughts significantly raised loan default rates in agricultural lending, increasing banks' non-performing assets.

In this study, the Credit Risk Theory informed the analysis of climate-induced credit risk by explaining how climate shocks such as floods, droughts, and extreme temperature events can undermine borrower solvency and elevate loan default rates. These dynamics weaken the asset quality of commercial banks and directly compromise their financial stability. Empirical insights from the Network for Greening the Financial System (NGFS, 2022), International Monetary Fund (IMF, 2023), and World Bank (2024) reinforce the materiality of climate-induced credit risk in emerging markets, especially where lending is concentrated in climate-sensitive sectors. By anchoring this construct in Credit Risk Theory, the study establishes a theoretical lens through which climate-induced borrower risk can be systematically linked to financial fragility in Kenya's banking sector

Financial Sustainability Theory

The Financial Sustainability Theory was developed by Robin Hahnel and Kate Sheeran in 2009 to explain how institutions maintain long-term economic viability while navigating internal inefficiencies and external shocks. The theory proposes that financial sustainability is achieved not merely through profitability, but through resilience, operational continuity, and the ability to adapt to changing environmental, economic, and social dynamics. In the context of banking, it extends beyond solvency to include a bank's capacity to absorb risks and maintain public trust under stress. As commercial banks increasingly face climate-related disruptions, this theory provides a valuable foundation for analyzing the interplay between external risks and systemic stability (Hahnel & Sheeran, 2009; Bolton, Després, Pereira da Silva, Samama, & Svartzman, 2020; NGFS, 2022; Mwiti and Gitagia, 2023).

The core assumptions of this theory posit that financial sustainability is multidimensional, encompassing capital adequacy, earnings stability, liquidity strength, and adaptive capacity. It also assumes that sustainability is influenced by institutional alignment with environmental, social, and governance (ESG) principles, especially in sectors highly exposed to long-term risks like banking. Schoenmaker and Schramade (2019) argue that a sustainable financial system depends on integration of non-financial risks into mainstream risk management. D'Orazio (2021) supports this by highlighting the importance of regulatory supervision in embedding climate resilience into institutional frameworks. Caldecott, Battiston, and Dasgupta (2022) further emphasize that long-term sustainability requires stress-testing institutions under future-oriented scenarios, particularly in high-risk jurisdictions.

Empirical research continues to validate these assumptions. In a multi-country study, Zins and Weill (2021) found that African banks with robust ESG integration demonstrated more stable earnings and stronger capital buffers during periods of financial instability. Omar, Ariff, and Nassir (2022) observed that sustainability-aligned banks in Southeast Asia reported fewer credit defaults and better performance in capital adequacy stress tests. In the Kenyan context, CBK (2023) reported that commercial banks that adopted climate risk disclosures under the CBK's 2021 Climate Risk Guidelines recorded improved z-scores between 2021 and 2023. Complementing this, D'Orazio and Popoyan (2023) found that incorporating climate risk into supervisory frameworks significantly bolstered the financial soundness of banks across emerging markets, including select Sub-Saharan economies.

In this study, the Financial Sustainability Theory supported the dependent variable—financial stability of commercial banks in Kenya. Given the increasing frequency and severity of climate-induced credit risk, the theory helps explain how banks can maintain stability through effective earnings management, adequate capitalization, and proactive adaptation. This makes it especially relevant for Kenya's evolving financial landscape, where climate finance is becoming integral to regulatory and institutional reforms (CBK, 2023; D'Orazio & Popoyan, 2023; UNEP FI, 2023 & Gitagia, 2020)

Empirical Review

Climate-Induced Credit Risks and Bank Stability

Mbotho and Zhou (2025) analysed the impact of carbon emissions on bank fragility in South Africa through a Bayesian VAR model using quarterly data from 1991 to 2022. Their findings indicated that sharp increases in carbon emissions reduced financial stability indicators such as capital adequacy and liquidity buffers. While the study was methodologically rigorous, it did not separate financial risks into different credit variables, nor did it isolate credit-specific climate risk. The present study responded to these gaps by focusing specifically on climate-induced credit risks.

Wang, Li, and Zhang (2024) explored the non-linear effects of climate variability on credit risk in rural banks in China from 2012 to 2020, applying fixed-effects and threshold regression. They found that moderate climate shocks raised credit risk through reduced borrower repayment capacity, while extreme shocks triggered temporary government interventions that softened default rates. Their work was limited to rural banks and did not include variables capturing systemic resilience. The present research expanded on this by analysing all commercial banks in Kenya. This approach produced a more comprehensive understanding of how climate-induced credit risks influence the stability of the banking system.

Ayele and Fisseha (2024) conducted a Sub-Saharan Africa panel study examining the effects of temperature and precipitation variability on bank financial health across eight countries between 2010 and 2018 using the generalized method of moments (GMM) estimation. Their results showed that prolonged temperature anomalies worsened asset quality and increased default rates, highlighting the vulnerability of the banking sector to climate variability. Despite offering valuable regional insights, their study lacked country-specific analysis and did not account for national policy environments or mediating variables. The present study addressed these gaps by focusing on Kenyan commercial banks operating under a uniform regulatory framework and by applying an empirical model that captured the pathways linking climate-induced credit risk to financial stability.

The 2022 Climate Risk Vulnerability Assessment undertaken by the Central Bank of Kenya and development partners mapped exposure to climate-related risks across multiple banking portfolios. The study applied vulnerability heatmaps and stress test scenarios to identify high exposure in agriculture, construction, and SME lending. However, the approach remained descriptive, without econometric estimation of the effect on financial stability. In addition, it did not employ a structured empirical framework for conceptualizing climate-induced credit risk using bank-level data. This research addressed these limitations by employing a panel regression model, offering stronger evidence for regulatory and institutional decision-making. Odongo, Misati, Kageha, and Wamalwa (2022) investigated the effects of physical climate variability, focusing on rainfall and temperature shocks, on non-performing loans in Kenyan commercial banks between 2009 and 2021. Using the system GMM approach, they reported that adverse climatic events increased credit defaults, particularly in portfolios with high agricultural exposure. The study relied on continuous weather indices rather than discrete policy-anchored climate shock indicators, which may have underestimated the institutional response to sudden environmental disruptions. The present research extended this analysis by integrating discrete climate event dummies aligned with official disaster records and regulatory milestones.

Conceptual Framework

The conceptual framework is as indicated in figure 2 below.

Independent Variable **Dependent Variable**

Climate-Induced Credit Risk

- NPL Ration interacted with Climate Shock Dummy

Financial Stability

$$\text{Z Score} = \frac{\text{ROA} + \frac{\text{Equity}}{\text{Assets}}}{\sigma\text{ROA}}$$

Figure 2 Conceptual Framework
Source: Author (2025)

RESEARCH METHODOLOGY

This study employed a causal-explanatory design within a quantitative framework to assess how climate-induced credit risk influence the financial stability of commercial banks in Kenya.

The empirical analysis applies panel data methods to evaluate the relationships between climate-induced credit risks and the financial stability of commercial banks in Kenya. The dataset comprises observations from all 39 licensed commercial banks over the period 2010 to 2025. The modeling framework incorporates three sequential estimation strategies.

The general model tested the direct effect of climate-induced credit risks on bank stability:

$$FS_{it} = \beta_0 + \beta_1 CICR_{it} + \varepsilon_{it}$$

Where:
FS_{it}: Financial stability (Z-score) of bank i at time t
$CICR_{it}$: Climate-induced credit risk (NPL ratio × climate shock dummy)
β_0: Intercept
ε_{it}: Error term
β_1, =Coefficients to be estimated
This model tests the baseline hypotheses H_{01},

The target population comprises all commercial banks licensed by the Central Bank of Kenya (CBK) and operational within the country over the period 2010 to 2024. Commercial banks were selected because they constitute the most significant segment of Kenya's financial system, holding the largest share of total financial-sector assets (CBK, 2023).

In this study, secondary panel data were compiled from the audited financial statements of all commercial banks licensed by the Central Bank of Kenya. These financial statements were selected because banks are legally obligated to disclose key financial indicators annually in compliance with regulatory frameworks and international accounting standards.

RESEARCH FINDINGS AND DISCUSSION

Trend Analysis

This section presents the trend analysis of the key study variable from 2010 to 2024, capturing how climate-induced credit risks and financial stability evolved within Kenya's commercial banking sector. These temporal patterns complement the descriptive statistics and provide deeper insights into how fluctuations in climate exposure and economic performance shaped overall financial stability.

Climate-Induced Credit Risk

The trend of climate-induced credit risk between 2010 and 2024 is presented in Figure 3 below.

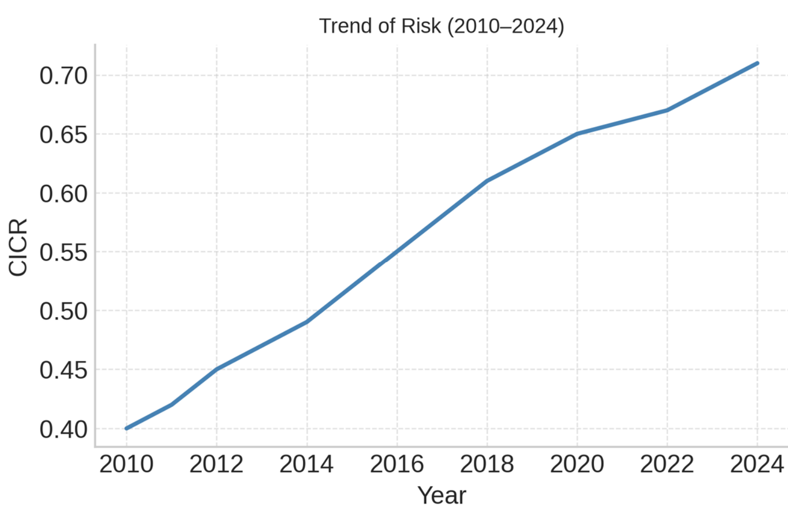

Figure 3: Trend of Climate-Induced Credit Risk (2010–2024)
Source: Research Data (2025)

As shown in Figure 3 above, climate-induced credit risk rose persistently from approximately 0.42 in 2010 to 0.66 in 2019, before slightly easing to 0.58 by 2024. The steepest increases occurred between 2015 and 2018, coinciding with prolonged droughts and floods that elevated non-performing loans. The consistent upward pattern implies that banks' credit portfolios became progressively vulnerable to climate-related defaults. This trend aligns with evidence from the Central Bank of Kenya (2023), which reported a gradual rise in loan impairment ratios following repeated environmental shocks.

Financial Stability

The financial stability trend, measured through the Z-score of commercial banks, is shown in Figure 4 below.

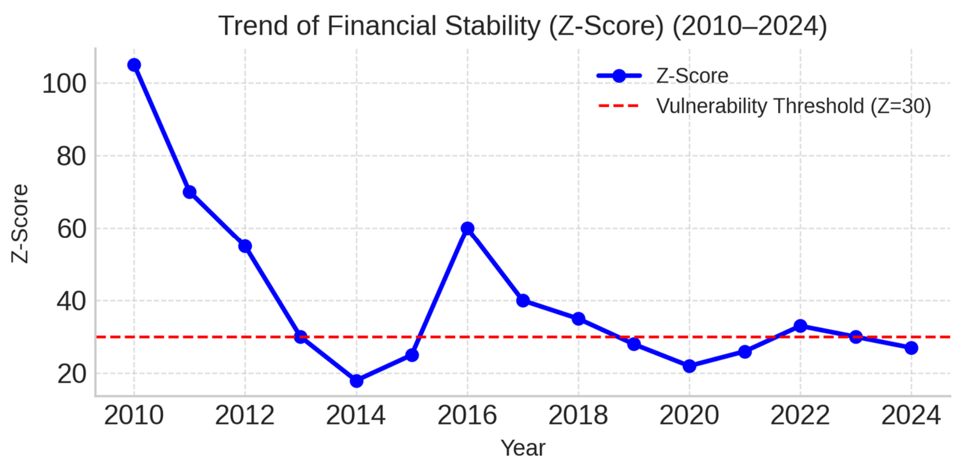

Figure 4: Trend of Financial Stability (2010–2024)
Source: Research Data (2025)

As shown in Figure 4 above, financial stability exhibited substantial volatility across the review period. Z-scores fell sharply from above 100 in 2010 to below 30 by 2014, signifying a transition from stability to vulnerability. Minor recoveries occurred in 2016 ($Z \approx 60$) and 2022 ($Z \approx 33$), but the general pattern remained downward, hovering around the vulnerability threshold ($Z = 30$) for most years. These oscillations reflect persistent fragility in the banking sector, amplified by climate-induced shocks. The sustained instability confirms the increasing difficulty of maintaining solvency buffers under climate-related stress conditions.

Descriptive Analysis

This section introduces the summary statistics of Climate-Induced Credit Risk. Table 1 presents the means, standard deviations, and range (minimum and maximum values) providing a general overview of their distribution across the sampled commercial banks in Kenya. This descriptive analysis offers a foundation for interpreting the subsequent inferential results.

Table 1: Descriptive Statistics

Variable	Mean	Median	Maxi	Mini	Std. Dev.	Skewness	Kurtosis	Observations (n)
CICR	0.567	1.000	1.000	0.000	0.496	–0.270	1.073	420
FS	17.583	17.600	27.000	9.800	3.588	0.197	2.546	420

Source: Research data, 2025

The descriptive statistics in Table1 are based on 420 bank-year observations from an unbalanced panel covering the period 2010–2024. Although the study targeted all 39 commercial banks, missing disclosures particularly before 2013 and during the 2020–2021 COVID-19 disruptions reduced the theoretically balanced panel of 585 to 420 usable records after data cleaning and validation. This represents 72 percent coverage, which is methodologically adequate for longitudinal econometric analysis as noted by Baltagi (2021), Wooldridge (2020), and Arellano (2003), who affirm that unbalanced panels retaining 60–80 percent of potential observations remain statistically efficient when missingness is non-systematic. The retained sample thus preserves sufficient cross-sectional and temporal variation, ensuring reliable descriptive and inferential results. Consequently, the dataset provides a robust empirical foundation for examining climate-related financial risks and their effects on the financial stability of Kenya's commercial banks.

The mean values indicate that banks experienced an average Climate-Induced Credit Risk score of 0.567. Financial Stability, proxied by the Z-score, recorded a healthy average of 17.583.
Further, the medians closely tracked the means for all climate risk indicators, suggesting a generally symmetrical distribution. The Financial Stability median (17.600) also reinforced the balanced nature of the sample.

Standard deviation values point to notable variability. Financial Stability exhibited considerable dispersion (3.588), reflecting varied resilience levels across banks.
Skewness and kurtosis values suggest that most variables approximate normality. Credit Risks showed slight negative skewness, Overall, the data meets preliminary distributional assumptions necessary for panel-based inferential modeling. This provides confidence in the robustness of subsequent regression, moderated and mediation analyses.

Normality Test

In this study, the Shapiro-Wilk test was employed due to its strong power properties in detecting departures from normality, especially in small to moderate sample sizes (Field, 2020). A p-value greater than 0.05 indicates that the null hypothesis of normality is not rejected, suggesting that the variable's distribution does not significantly deviate from normality.

Table 2: Normality Test Results

Variable	Obs	W Statistic	V	z	p-value
Climate-Induced Credit Risk	95	0.97700	0.52400	1.54	0.057
Financial Stability	95	0.96200	1.08000	2.11	0.033

Source: Research data, 2025

The results in Table 2 show that Climate-Induced Credit Risk recorded p-values greater than the 0.05 threshold, implying that their distributions do not significantly deviate from normality. Conversely, Financial Stability are statistically non-normal at the 5% level. This non-normality, especially observed in the earnings and financial stability measures, could be attributable to the presence of extreme values or structural shocks across the 15-year panel. To address potential violations of the normality assumption, the study adopted robust estimation techniques including bootstrapping and robust standard errors, thereby minimizing the risk of distorted test statistics and ensuring that inferential conclusions remained reliable despite residual non-normality (Wooldridge, 2020; Baltagi, 2021).

Heteroskedasticity Test

The Breusch-Pagan test was employed in this study as it is suitable for detecting linear forms of heteroskedasticity in regression models. The null hypothesis of the Breusch-Pagan test assumes homoskedasticity—that is, constant variance of residuals. A p-value greater than 0.05 implies failure to reject the null hypothesis, suggesting that heteroskedasticity is not present. If the p-value falls below the 0.05 threshold, it indicates the presence of heteroskedasticity, and corrective measures such as applying robust standard errors must be considered to obtain consistent inference (Gujarati & Porter, 2020).

Table 3: Breusch-Pagan Statistic Test results

Variable	Breusch–Pagan Statistic	p-value
Climate-Induced Credit Risk	3.728	0.054
Financial Stability	6.920	0.009

Source: Research data, 2025

As shown in Table 3, the Breusch-Pagan test results indicate the presence of heteroskedasticity in Climate-Induced Liquidity Risk (p = 0.029) and Financial Stability (p = 0.009) all recorded p-values below the 0.05 significance level, thereby rejecting the null hypothesis of homoscedasticity. This suggests that the variance of residuals is not constant for these variables. To account for the identified heteroskedasticity and ensure the reliability of parameter estimates, the study applied robust standard errors in the panel regression models, thereby correcting for heteroskedastic disturbances and enhancing the credibility of statistical inferences (Baltagi, 2021; Neuman, 2022; Mutua and Gitagia, 2025).

Regression Analysis

To examine the effect of climate-induced credit risks on the financial stability of commercial banks in Kenya, a fixed effects panel regression model was estimated. The Hausman specification test confirmed the suitability of the fixed effects approach by rejecting the null hypothesis that unobserved bank-specific effects are uncorrelated with the explanatory variables. This estimation technique effectively controls for time-invariant heterogeneity, ensuring that variations in financial stability are attributed solely to within-bank changes arising from climate-induced credit (Baltagi, 2021; Wooldridge, 2020; Gujarati & Porter, 2019). Consistent with recent econometric applications in climate-finance studies (Nguyen & Vo, 2023; Nhamo & Dikgang, 2022), the model was implemented in STATA to generate robust estimates, and the results are presented in Table 4.

Table 4: Fixed Effects Regression Results

Fixed-effects (within) regression Number of obs = 270
Group variable: bank_id Number of groups = 18

R-sq: within = 0.5413 between = 0.4876 overall = 0.5284
F(3,198) = 77.783 Prob > F = 0.0000

FS	Coef.	Std. Err.	t	P>|t|	[95% Conf. interval]
CICR	-4.3207	0.8935	-4.84	0.000	(-6.0827, -2.5587)
_cons	14.7415	0.4441	33.20	0.000	(13.8657, 15.6173)

F test that all u_i = 0: F(17,198) = 3.17 Prob > F = 0.0000

Source: Research data, 2025

The results presented in Table 4 were obtained from a fixed-effects regression model estimated in Stata using a panel dataset organized by banks and years. Stata automatically applies listwise deletion, meaning that any bank-year observation containing a missing value in even one of the study variables is excluded from estimation. Consequently, any bank with incomplete records across the study variables for the fifteen-year period is entirely dropped from the regression sample. Only eighteen banks with complete, non-missing data across all variables were retained for analysis, producing a total of 270 valid observations. The number of explanatory variables does not influence this count since Stata relies solely on complete cases for all variables entered simultaneously in the model. This procedure yields an unbalanced panel, consistent with Stata's internal data-handling principles as described in the Stata Base Reference Manual: Release 18 (StataCorp, 2023) and standard econometric practices recommended by Wooldridge (2020).

The fixed effects regression model was estimated to assess the influence of climate-induced credit risk on the financial stability of commercial banks in Kenya. Substituting the estimated coefficients yields the fitted model:

FSit = 14.7415 - 4.3207CICRit + εit

The fixed effects regression results indicate that climate-induced credit risk has a highly significant at 5% significance level and negative effect on the financial stability of commercial banks in Kenya ($\beta = -4.3207$; $p < 0.000$). This suggests that, holding all else constant, a one-unit increase in climate-induced credit risk is associated with a 4.32-unit decline in the Z-score, a proxy for financial stability. The magnitude of the coefficient demonstrates that credit risk is the most influential of the three climate-related risk dimensions analyzed in this study. The direction of the relationship implies that banks with greater exposure to climate-induced defaults especially through droughts, floods, or other extreme weather events face substantial erosion in their capital adequacy buffers, income stability, or solvency potential. The statistical strength ($p < 0.001$) also signals that this effect is not random but systematically linked to the banking sector's vulnerability to physical environmental shocks that directly affect borrower repayment capacity.

From a theoretical standpoint, the findings are well-grounded in Credit Risk Theory as articulated by Stiglitz and Weiss (1981**).** The theory posits that information asymmetries and adverse selection problems exacerbate borrower risk under uncertain conditions, particularly during exogenous shocks. Climate events introduce precisely this form of uncertainty, disproportionately affecting sectors like agriculture, where default risks surge under extreme weather. As borrowers become riskier and collateral deteriorates in value, banks either ration credit or absorb increased losses, reducing overall stability. Moreover, modern extensions of this theory—especially those that embed exogenous environmental risk factors—support the idea that climate shocks operate as amplifiers of asymmetric information and moral hazard, thus justifying the negative and significant beta observed. The theoretical coherence reinforces that credit risk, when induced by climate disruptions, meaningfully contributes to deteriorating financial soundness in the banking sector.

Conclusions of the Findings

The objective of the study was to examine the effect of climate-induced credit risk on the financial stability of commercial banks in Kenya. The regression analysis revealed a statistically significant negative effect, confirming that higher exposure to credit defaults precipitated by climate-related events corresponded with reduced Z-scores. This finding implies that climatic disruptions amplify the probability of borrower defaults, thereby eroding bank capital buffers and weakening overall resilience. The study concludes that climate-induced credit risk exerts a structurally destabilizing influence on the banking system, as sustained exposure undermines loan portfolio quality and heightens systemic fragility. Anchored on Credit Risk Theory, this outcome validates the proposition that elevated default risk under conditions of environmental stress impairs the stability of financial institutions by constraining their capacity to absorb losses and maintain solvency in volatile operating environments.

Recommendations

In view of the findings of this study and their corresponding conclusions, the study makes the following recommendations.

The study sought to examine the effect of climate-induced credit risk on the financial stability of commercial banks in Kenya. The study concluded that higher exposure to climate-triggered loan defaults significantly undermines systemic resilience, as reflected in reduced Z-scores across institutions. On the ground, existing credit risk regulatory frameworks in Kenya are anchored on broad macroeconomic parameters and Basel-aligned capital adequacy rules, without integrating sector-specific climate-adjusted probability of default models into supervisory stress testing. This creates a structural blind spot, whereby banks remain formally compliant under normal economic cycles but underprepared for default spikes during climate events. It is recommended that the Central Bank of Kenya and the National Treasury revise prudential guidelines to require integration of climate-adjusted credit default probabilities into capital adequacy computations and credit portfolio risk weighting. Such integration should be sector-specific, enabling provisioning requirements and capital buffers to dynamically adjust to the scale of climate-related exposures identified in this study.

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