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CLIMATE RELATED RISKS AND ITS IMPACTS ON THE FINANCIAL HEALTH OF PAKISTANI BANKS: MODERATING ROLE OF GREEN BANKING

By:

Filza Kashif **01-222241-020**

Supervisor:

Prof. Dr. Muhammad Naveed

Finance And Accounting Department

Bahria Business School

Bahria University Islamabad

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Names of Student: FILZA KASHIF Enroll # 01-222241-020

Class: (MBA 2 year)

Approved by:

_____

(prof. Dr. Muhammad Naveed)

Supervisor

_____

Examiner-I

_____

Examiner-II

_____

Qurat Ul Ain Waqar

Research Coordinator

_____

Dr. Khalid Hussain

Head of Department

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Abstract

Climate change is a new source of financial risk exposure for the banking system, especially for those economies that are highly susceptible to climate change. This research explores the implications of financial risks posed by climate change on financial health of banks in Pakistan through the NPL ratio method. The study explores the importance of green banking practices while making the banking system more robust against financial risks posed by climate change. The research design is quantitative. The study examines panel data for 19 publicly listed commercial banks over 2015-2024.This analysis considers both physical risks associated with climate change, such as flood, drought, mass movements (wet or dry), air pollution, and extreme weather, and transition risks that may arise from changes in policies/factors that exert pressure on a low-carbon economy. This study also tests whether green banking operations through Environmental, Social, and Governance (ESG) factors helps ameliorate risks posed by climatic changes on banks' asset quality. The empirical results indicate that both physical and transition climate risks significantly heighten banks' NPL ratios, indicating heightened credit risk because the climate-related shocks deteriorate borrowers' debt-repaying ability. However, the findings also show that in the presence of sound green banking practices, banks exhibit low sensitivity of NPLs to climate risks, thereby inferring crucial roles that a greener lending policy and reinforced risk management frameworks play in cushioning climate-induced credit deterioration. This study pinpoints how the strategic importance of embedding green banking at the heart of core banking operations is not only underway to enhance environmental sustainability but also to enhance credit risk management and assure financial stability. These findings provide actionable insights for bank management and policymakers seeking to develop climate-resilient banking strategies in emerging markets.

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CHAPTER 01

1. INTRODUCTION

The importance of the study arises with regard to the efforts geared towards identifying the possible effects of climate change risk on financial stability as well as bank health in the Pakistani context in view of the moderating role that might be developed through green banking. In this context, the quantitative study will be used in the context that the study plans to apply panel data analysis over the years 2015 to 2024 with the assumption that Physical Climate Risks of the type flood, drought, mass movement (wet and dry), Air Quality, as well as Extreme Temperature; Climate Transition Risks - regulation/transition to Low Carbon Economy will negatively affect the banks.

The evaluation criteria include consideration of a set of key performance measures but the main focus remain on the NPL ratio, which determine the credit position of the banking sector relative to its assets. In additional analysis, the work also investigates if Green Banking practices, in the form of using Environmental and Social Governance factors, are used to offset risks brought forth by the effects of risks related to climate change in the banking sector financially.

Empirical research findings indicate that both the physical and transitional risks of climate have a negative influence on the financial condition of banks in terms of reduced profits, increased credit risks, and pressures on their capital ratios. On the contrary, research findings indicate that banks that actively pursue green banking are more resilient in times of climate shocks. Green banking practices significantly mitigate climate risks by improving risk management capabilities. The impact of climate risks on the financial condition of banks can be mitigated through green banking practices by improving their risk management abilities.

The relevance of aligning the initiatives on green banking with the functioning of the banks has been established in the study, and it has become the agenda not only for the sustainability cause but also for the resilience of the banking system against the challenges of climate change. The study offers a valuable learning for the management of the banks

1.1 Background of study

There has been a paradigm shift in the connection between climate change and financial systems in the last two decades. Climate-related occurrences in earlier finance studies were exogenous

phenomena with minimal implications for banking performance metrics. The conventional risk management paradigms have largely been concerned with credit risk, market risk, and operational risk with a tacit belief in environment-related factors as non-systemic phenomena with a temporary character. But with the rise in the intensity and financial severity of climate-related phenomena, climate change has been newly framed as a structural driver of financial stability (Campiglio et al., 2018; IMF, 2025).

It has become apparent in recent global finance crises, which have been triggered or worsened by climate shocks, that climate change can have an impact on banks via several channels. These channels include degradation of the capacity of borrowers to repay their loans, degradation of asset values, business disruptions, and heightened uncertainties surrounding capital planning decisions. Consequently, there has been a growing concern among international finance bodies and supervisors to mainstream climate risks into prudential supervision (FSB, 2025; BIS, 2021).

Within the realm of published research, initial empirics concentrated on material climate-related threats, analyzing conditional relationships between weather events affecting crop production series, household income, as well as individual firm performance. Later research reinforced these findings for banking industry performance because floods, droughts, heatwaves result not only in rising non-performing loans but also have a detrimental effect on banking profitability for developing countries with climate-vulnerable regimes (Rehman et al., 2021; Alam et al., 2021; Kuntz et al., 2024).

More recently, the literature has been extended to cover climate transition risks to account for the financial effects of the world's transition towards the low-carbon economy. Climate transition risks can be described as the effects of policy transitions like carbon pricing policies, emission policies, climate disclosure policies, as well as innovation in technology that changes production patterns and energy consumption. Credit institutions that are heavily exposed to carbon resource-intensive activities face the risk of lowering their property values through write-offs in the event of transitions of the world's economies towards sustainable growth patterns (ECB, 2020; Campiglio et al., 2018). Even though climate transition risk has drawn increasing focus worldwide, there is still inadequate empirical evidence within the emerging markets due to lack of uniform transitions in the regulatory policies as well as less diversified financial sectors (Kamran et al., 2020; Al Frijat et al., 2025).

Concurrent with the identification of climate-related financial risks, green banking stands out as a relevant institutional mechanism within the financial sector. Green banking may be understood to be the integration of environmental, societal, and governance (ESG) factors into the processes and practices associated with banks. In past research, green banking was considered a reputation-driven and societal initiative, while the most recent work defines it as a mechanism that can be leveraged to improve financial resilience and stability (Khan et al., 2023; Iqbal et al., 2024).

Evidence shows banks that are involved in green financing, ESG transparency, and sustainable loan practices have better risk management, heightened stakeholder trust, and better regulatory compliance (Muchiri et al., 2025; Elshamly et al., 2023). Green instruments, green bonds, and sustainability-linked loans have also allowed banks to raise capital for environmentally responsible practices, thus minimizing their portfolio exposure to climate-sensitive instruments. However, the potential of green banking practices as a moderating variable, as opposed to simple green banking practices, is still an uncharted territory, especially within the context of emerging nations.

What makes these matters more relevant is that they can have a significant impact on Pakistan, a country that is most vulnerable to climate change. Pakistan has always been ranked among the most vulnerable nations when it comes to climate change. Pakistan is a climate-vulnerable country primarily owing to its geographical position and reliance on agricultural land. Disasters that may be climate change-related, like the flood of 2010 and 2022, have negatively impacted Pakistan's economy and have hampered the capacity of borrowers to pay back banks (World Bank, 2023; UNDRR, 2022).

The Pakistani banking system is a key financial system that funds climate-smensitive industries such as agriculture, energy, and small and medium-scale industries. Therefore, climate-related physical risks can be measured in terms of credit risk, which increases due to rising non-performing loans. On the contrary, risk of climate change transitions can pose serious risks in terms of long-term profitability and capital adequacy in the future. The State Bank of Pakistan has acknowledged these issues by introducing policies such as Environmental and Social Risk Management (ESRM) guidelines that encourage banking institutions to incorporate sustainability features in their activities (State Bank of Pakistan, 2022).

The current body of research on Pakistan has been covering the resilience issues related to climate risks or the adoption process of green banking in a separate manner, without incorporating physical risks, transition risks, and financial resilience in an integrated framework. Furthermore, there has

been minimal consideration of the resilience indicators related to capital, including Capital Adequacy Ratio (CAR), which is very essential in determining the banks' capacity to tackle financial risks triggered by climate change. This is an important gap in the literature related to the context of Pakistan.

It is against the above highlighted challenge that the current study is based on the rationale of providing a comprehensive analysis on the financial risks associated with climate change in the Pakistani banking industry. This study will focus on the physical and transition risks within the time frame of 2015-2024 and will identify the effect on the key indicators of financial health ssof the banking industry. This piece of work will also contribute towards the concept that a sustainability-based approach can result in increased resilience of banks towards a vulnerable emerging country like Pakistan because the current piece will model the green banking orientation as a moderating variable.

1.2 Problem Statement

It is evident that intensifying levels of climate change have also become a significant challenge faced by the global banking and finance sector. Risks associated with climate change, including physical risks like floods, droughts, and heatwaves, and transition risks associated with regulatory changes, technological innovation, and market transition due to shifting economic systems toward low-carbon economies, have transformed the risk profile faced by banks. These emerging realities have forced banks worldwide to rethink their approach toward traditional risk management, given that risks associated with climate change directly correspond to credit risks, operational risks, and risks related to adequate capital levels. Though global regulators and banks are well aware that climate-related risks have become significant financial risks, their impact at the level of banks is still being explored in emerging economies.

Keeping in view the empirical literature on the subject reviewed across developed and emerging countries, the issue of climate risks and the performance of the banking sector has also been highlighted. However, the current state of scientific knowledge on the subject is that the area of climate risks and the performance of the banking sector, including Pakistani banks, is less explored compared to the existing works on macroeconomic climate risks or the specific sectors that are affected. This study attempts to fill the gap on the subject matter from the point of view of climate risk exposure and the financial health of the Pakistani banks.

In the context of the preceding discussion, the topic of interest for this research work includes three significant strands. Firstly, the significance of this research work includes the aspect of highlighting the need to examine the effects of physical climate risks like floods, droughts, and heatwaves on the financial position of Pakistani banks. Since banking exposure lies in the climate-sensitive sectors of agriculture, energy, and small and medium-scale enterprises, it becomes a significant aspect to understand the effects of physical climate risks on the financial health and capital positions of the respective banking sector.

Second, the study considers the state of climate transition risk, which has mushroomed due to the world's transition to a low-carbon economy. Driven by policy-induced regulatory changes, innovation in technology, and market forces aimed at cutting carbon emissions, climate transition risk may exacerbate banks' vulnerability-in particular, through the channels of deterioration of asset values, higher default risk, or pressure on capital adequacy as industries update themselves in response to changes impelled by transition. This study analyzes whether these climate transition risks exert a measurable impact on the financial position of Pakistani banks, particularly by influencing their exposure to credit risk in an increasingly regulated and sustainability-oriented economic environment.

Lastly, the study also examines the moderating effects of green banking practices on the relationship between climate risk and financial health. Given the growing trend of green banking practices among banking institutions, including ESG considerations in banking investments, green loans, as well as sustainable banking policies, it is important to determine the potential for green banking as just another means of fulfilling institution obligations in terms of compliance as well. Via the application of the holistic method for study plan formulation in this study above, the question of whether financial sustainability through green banking practices has the ability to positively impact the risk management system of Pakistani banking institutions is ascertained.

1.3 Research Gap

There is a substantial lack of research in existing knowledge related to banking and emerging countries like Pakistan in particular with regard to interrelationship between climate change and financial outcomes at a banking level. Current research is focused either on macroeconomic effects of climate change or micro-level vulnerability with regard to environment risk.

First, it is noticeable that the current body of evidence stresses physical risks rather than the role of transition risks linked with regulatory transitions and market shifts to support the low-carbon economy. Alternatively, when focusing on the role of transition risks, it is observable that evidence has been mostly collected from developed countries; yet, an evident gap exists regarding the study of the risks associated with banks in emergent markets based on their capacities to manage related risks.

Second, most empirical research focuses on climate change risks and bank performance individually rather than considering both together. The indicators considered by these studies include bank profit and credit risks but not overall bank financial soundness measurements, mainly efficiency, capital resilience, and so on. The neglect to include measurements for capital resilience, results in research being unable to measure a bank's resistance to climate change when it comes to shocks.

Thirdly, in terms of the perspective that green banking practices have attracted more scholarly focus and concern from regulators in recent years, in the current literature, there is a lack of empirical analysis focusing on green banking practices as a moderating factor that can change the degree of relationship between climate risk factors and the financial position of banking institutions. This can be seen in relation to studies based in Pakistan, which lack adequate data on the extent to which green banking practices can contribute towards lessening climate change-related financial risk factors.

Finally, current literature is based on cross-sectional research or short-term series, which limits the analysis of changes over time of climate/transition risks in relation to banking system stability over time. It is apparent that there is a big gap in research based on panel data analysis of banks over time to examine the relationship of climate risks with banking through green banking activities for a considerable period of time in climate-exposed countries.

In light of such gaps, this study fills the gap by conducting a comprehensive empirical study of the impact of climate risks, the role of green banking practices in moderating such risks, and financial performance of the major Pakistani banks simultaneously in the period 2015 to 2024. This study fills an important gap in the literature of climate finance by considering multiple risk sources, financial performance measures, and financial indicators in a single framework of study, thereby adding a new insight in the study of climate finance.

1.4 Research Questions

- What is the impact of climate-related physical risks on financial health of Pakistani banking industry?
- Whether and how climate related transition risks affect banks' financial health??
- How green banking practices mitigate the effect of climate-related physical and transition risks on physical health of Pakistani banks

1.4 Research Objective

• To examine the impact of climate-related physical risks on the financial health of the Pakistani banking industry.

• To analyze the effect of climate-related transition risks on the financial health of banks operating in Pakistan.

• To assess the role of green banking practices in mitigating the effects of climate-related physical and transition risks on the financial health of Pakistani banks.

1.6 Significance of study

This paper has great relevance for the banking industry, regulators, policymakers, and institutions of higher learning since it offers empirical evidence on how climate-related risks influence the financial sustainability of banks operating in Pakistan. Through an assessment of the effect caused by physical climate risks and transition risks on banks' profitability, asset quality, and capital sufficiency, this paper empowers bank managers with valuable knowledge on how to make strategic orientations on risk management and resource allocation better informed through sensitivity to climate change risks that may disrupt bank operations.

On the regulatory and policy front, the results obtained in this research work have provided evidence-based information that could aid in the development and furtherance of policies regarding financial regulation related to climate. The policymakers and financial authorities, especially the State Bank of Pakistan, would be able to derive benefits from the results and come up with strategies regarding the need to improve the regulation related to the oversight of risks associated with climate in their supervisory framework.

It is worth noting that the importance of green banking practices as a means of managing climatic financial risk is also emphasized in the study. The study helps banks understand whether sustainability practices like ESG integration, green lending, and green investments actually contribute towards improving the financial resilience of banks rather than acting as a mere means of fulfilling obligations. This will enable the banks to formulate green banking practices that will effectively meet the objectives of green banking while ensuring that they perform well financially. On a sectoral perspective, the research draws attention to the banking system's contribution to Pakistani climate adaptation goals through sustainable development channels. With banks being climate-risk sensitive to agriculture, energy resources, and small to medium-sized enterprises, analyzing climate risk transfer is essential to guarantee continued credit financing for non-hardware sectors while containing systemic risks to banking systems. On a monetary perspective, findings can shape banking strategies for long-term resource allocation for sustainable activities contributing to economic development and climate resilience for Pakistan.

From a research perspective, the significance of this study primarily stems from the focus it places upon addressing critical research gaps associated with climate finance within the context of emerging economies. This particular study differs from the past literature because it considers climate risks, risks associated with the transition process, and green banking practices together as a whole within a single study at the bank level instead of concentrating upon individual aspects within the research. The use of various financial indicators, including capital adequacy ratios, within the study increases the objectivity of research findings associated with banks' resilience to any climate-related shocks.

Lastly, the research work lays a future path for research work in that it gives a systematic empirical framework that can be further extended to other emerging markets/economies or financial institutions. Findings from the research work can therefore inform future research in climate risk modeling tools, sustainable financial products, and the long-run effects of green banking on financial stability. In conclusion, this research work contributes towards paving the way towards a more sustainable and climate-conscious banking system in Pakistan.

CHAPTER 02

2. LITERATURE REVIEW

2.1 Definitions:

Independent Variables:

Climate Risk (Physical Climate Risk)

Climate risk, especially physical climate risk, is defined as the exposure of banks to financial and operational losses due to climatic events such as floods, heatwaves, drought, and extreme weather conditions. These events disrupt economic activity, physically damage infrastructure, and diminish borrowers' capacity for repayment, which in turn raises credit risk and non-performing loans. Physical climate risk reflects the vulnerability of banks operating in climate-sensitive regions and sectors and is an increasingly significant threat to financial stability in developing economies like Pakistan.

Climate Transition Risk

Climate transition risk is a financial risk related to the transition to a low-carbon, environmentally sustainable economy. These risks arise from changes in climate-related regulations, environmental policies, technological change, and market preferences that are being pursued for the purpose of economically internalizing carbon emissions. For banks, the emergence of transition risks could lead to devaluation, stranding of assets, increased risk of default, and strains on profitability and capital adequacy, particularly for banks with significant exposures to carbon-dependent sectors.

Dependent Variable

Financial Health of Pakistani Banks

The financial health of banks represents their capacity to maintain stability and their ability to operate in the face of economic and environmental changes. This represents the effectiveness of the banks in managing their credit risks. Although this study has explored a variety of financial stress measures like Return on Assets, Return on Equity, and the Capital Adequacy Ratio, the primary emphasis has been on the NPL ratio since this ratio is a direct indicator of the exposure of banks to credit risks. Since the type of climate change impacts that banks are exposed to are in the form of physical and transition risks that tend to impact the ability of the debtors in directly paying

back their loans, in this case, the NPL ratio represents the direct indicator of the impact of climate change on the financial resilience of the banks in Pakistan.

Moderating Variable

Green Banking Practices

The best definition of green banking practices can be described as the integration of environment, social, and governance principles into banking operations, lending policy, investment decisions, and risk management frameworks. These activities will involve green lending, financing of various environmentally viable projects, ESG disclosure, and environmentally responsible operational initiatives. Green banking therefore hopes to achieve sustainability with increased financial resilience by mitigating the negative impact of climate and transition risks and supporting long-term financial stability.

Control Variables

Bank Growth

The growth of a bank is understood to be the expansion of its operations and activities in financial services over time, and commonly can be measured through change in total assets, volume of lending, or revenue. Growth reflects a bank's ability to expand its market presence and influences its risk-taking behavior and financial performance.

Bank Size

Bank size reflects the scale of a banking institution and is usually measured by total assets. Larger banks tend to be more diversified, have thicker capital buffers, and thus have better abilities to absorb financial shocks than smaller banks.

Gross Domestic Product - GDP

Gross Domestic Product is the total value of the goods and services produced within the country in a certain period, and it reflects the overall indication of economic activities. GDP growth affects the banking sector performance because credit demand, investment opportunities, and the borrowing clients' repayment capacity change with the variation in the rate of growth.

Inflation Rate

The inflation rate is the rate at which the general price level of goods and services is rising, thereby eroding the purchasing power of money. Inflation impacts banks through its effects on interest rates, operating costs, and credit risk; hence it is included as a control variable at the macroeconomic level in this study.

2.2 Variable specific Literature Review

Climate Risks and the Financial Condition of Banks

Physical risks associated with climate change have recently attracted consideration in financial and banking literature in view of their positive and indirect influences on economic activities as well as financial system stability. Physical risks associated with climate change refer to risks associated with floods, droughts, heatwaves, and storm intensity, which affect production activities in various ways (IPCC, 2021). The activities are directly related to loan repayment cushions in the sense that they directly influence loan repayment capacities in the banking sector.

There are empirical studies showing banks operating in vulnerable climates that faced adverse weather conditions experience deterioration in their asset quality and profitability. Addoum et al. (2020) demonstrated banks at risk due to natural disasters experience severe deterioration in their loan performance, with high possibilities of defaulting. Consequently, climate shocks lead to enhanced credit risks with diminished lending capacities, especially for developing countries due to low insurance penetration and disaster preparedness (Kahn et al., 2021). Physical risks influence banks' business continuity by causing destruction to banking branches, technology, and collateral (Batten et al., 2020).

Emerging countries are more adversely affected by the impact of physical climate risks, which is accompanied by certain structural elements of these countries that are more dependent on climate-sensitive sectors such as agriculture and energy. This is supported by a study conducted by Rehman et al. (2021), which showed that floods and drought have a significant impact on the default of agriculture loans, which causes an increase in non-performing loans with lower bank profitability in Pakistan. Alam et al. (2021) stated that climate variability negatively impacts bank stability for South Asia's economy via credit risk and return volatility.

From the perspective of financial performance, literature suggests that physical risks of climate have adverse effects on Return on Assets (ROA) and Return on Equity (ROE) simultaneously. Pankratz and Zeisberger (2021) find that organizations and financial entities facing risks from climate change have lower profitability and higher volatility in earnings. Further, losses caused by climate can reduce banks' buffers, resulting in pressure on Capital Adequacy Ratios (CAR) due to their inability to absorb adverse fluctuations resulting from unexpected crises in the future (IMF, 2022).

In general, there is a concern that PCCs could cause a significant risk to banks' financial positions with respect to credit risk, profitability, and capital adequacy. It seems that there is a lack of empirical study for developing countries that could be affected by climate change in regions such as Pakistan.

Climate Transition Risk and Financial Soundness of Banks

Risks associated with the climate transition are brought about by the transition of the world towards a low carbon economy because of climate policies, regulations, technological change, and shifts in preferences (FSB, 2020). The risk posed to banks comes through their exposure to carbon-intensive sectors that could witness lower demand, higher costs of compliance, and stranded assets as a result of tougher climate regulations.

There are a few studies that indicate risks in the transition can strongly impact the risk profiles or value of assets of banks. Bolton & Kacperczyk (2021) found that when a company has high carbon emissions, there would be a corresponding increase in financial costs because of which credit risk would increase in banks. According to a study by the ECB in 2020, banks that have a high exposure to the fossil fuel industry can experience sudden changes in the value of their assets due to strict climate policies.

Technological Change

Technological change is also a significant factor in transition risk. The quick advancement of renewable energy sources and electric vehicles could make existing carbon assets obsolete, decreasing the value of collateral and increasing loan losses (Campiglio et al., 2018). According to Krueger et al., financial institutions tend to underestimate the risk of transition because of uncertainties about the timing and force of policy measures, which causes sudden changes in asset repricing (Krueger et al., 2020).

Evidence from emerging economies further verifies that risks of transition make long-term impacts on the profitability and capital position of banks. Kamran et al. (2020) showed that banks in emerging countries that rely heavily on environmentally vulnerable sectors face greater risks of earnings variability and capital strain. Al-Frijat et al. (2025) presented evidence that sectorial credit risks in developing countries rise drastically due to changes in transition laws.

Regarding the Pakistan scenario, the challenges that the transition towards sustainable and climate-friendly regulatory frameworks pose to the banking industry are multifaceted. Those banks that finance the conventional energy, manufacturing, and transportation sectors could get vulnerable to

the threat of defaults because of changing environmental rules (SBP, 2022). However, the existing literature gap indicates that there is a lack of empirical evidence that investigates the relationship between transition risk and the ROA, ROE, NPLs, and CAR of Pakistani banks.

Green banking practices and financial sustainability of banks

Green banking is a consequent measure that has cropped up in response to climate-related financial risks. It has highlighted the integration of Environmental, Social, and Governance (ESG) values and practices into banking. Green banking practices encompass green lending, sustainable investments, ESG disclosures, and environmentally mindful operations (Bose et al., 2021).

According to existing theory, green banking can contribute positively to the resilience of financial institutions by improving risk management and minimizing vulnerability to climate-sensitive assets. For instance, Weber (2012) suggests that improved risk management with regard to climate change can enable a bank to identify risks associated with credit in the event of climate change. Iqbal et al. (2024) conclude that financial institutions with well-organized green financing programs have improved financial stability and reduced credit risk.

Empirical research also reveals a positive correlation between ESG results and bank profitability. According to Khan et al. (2023), green banking practices improve reputation and investor trust, which ultimately leads to an increase in the ratio of return on assets (ROA) and return on equity (ROE) for a bank. Buallay (2019) finds that banks focusing on ESG perform better than regular banks, especially during a recession.

In a moderating capacity, green banking can be considered as a tool that helps in mitigating the financial risk implications associated with climate risks and transition risks. In this perspective, according to Delis et al. (2019), environmentally responsible green banking involves a change in the loans and investments channels of high-risk and high-carbon businesses to avoid transition risks. Muchiri et al. (2025) clarify that despite increased awareness of green banking in most industries and organizations around the world, its success lies in its level of implementation in risk management processes and systems.

In the Pakistani context, green banking is in its infancy phase due to regulatory recommendations issued by the State Bank of Pakistan in the context of its Environmental and Social Risk Management (ESRM) policy. It is opined by Rehman et al. (2021) that the lack of technical capacity for ESG disclosure affects the efficiency of green banking in the mitigation of climate

risk. There is thus the need for the empirical assessment of green banking as a moderating variable in the context of the Pakistani banking industry.

Financial Condition of Banks

Financial performance is a measure of a bank's capacity to create sustainable profits and manage credit risk effectively as well as have adequate buffers of capitals against any shocks. ROA and ROE measure a bank's efficiency and profitability; NPL measures a bank's quality and credit risk; and CAR measures a bank's capacity against any shocks and compliance with regulatory requirements (Ghosh, 2015).

The role of climate shocks has been encompassed in the existing literature as factors that directly affect the above indicators. Higher Non-Performing Loans (NPLs), which result after climate shocks, affect a bank's profitability and capital adequacy ratios, which limit banks' lending capabilities (IMF, 2022). Banks with strong capital bases and robust risk management structures can withstand environmentally related shocks (BCBS, 2021).

Although there has been increasing recognition of the risk of climate change, there has been a gap in the literature as financial health indicators have been studied separately or emerging countries with a vulnerable climate have not had a comprehensive analytical framework for the variables of risk associated with climate change and financial health indicators.

Green banking practices and climate change risk management

Green banking practices have recently become a strategic approach in countering financial risks associated with climate changes by embracing Environmental, Social, and Governance (ESG) factors in banks' operations, lending, and risk management strategies. Green banking helps reduce financial risk associated with climate changes by ensuring sustainable investment in the environment, enhancing risk screening, and making institutions resilient to financial risk. With the increasing manifestation of financial risks associated with climate change in the form of physical events and transitions, green banking practices have recently become prominent in managing financial risks in financial institutions (Weber, 2012; Campiglio et al., 2018).

A few studies suggest that green banking practices improve a bank's risk management capabilities when it comes to climate risks. Batten et al. in 2020 found that if banks take into account environmental risk variables in their credit decisions, they are more capable of mitigating climate-sensitive risk assets. Similarly, a study carried out by Delis et al. in 2019 revealed that sustainable

lending practices result in a bank mitigating climate risk by diversifying away from carbon-related industries.

Empirical evidence indicates that green banking practices result in better asset quality and less risk-taking behavior. Iqbal et al. (2024) indicate that banks that perform well on ESG factors record smaller percentages of non-performing loans and more steady earnings performance, implying that they are more resilient to external shocks. Khan et al. (2023) indicate that green banking practices enhance stakeholder confidence and reputational capital, implying that they result in indirect improvements in financial performance and risk management.

In the case of the emerging economy, the development of the relevant frameworks is still underway, resulting in green banking contributing towards filling the institutional gap. According to Muchiri et al., (2025), green banking programs ensure banks factor the climate risks that are considered within the externality of risk management frameworks within banks through focusing on climate change rather than neglecting it when managing risks. Such processes cannot be relied upon when they lack meaningful integration rather than superficial ESG performance.

Climate Risk Governance and Monitoring Mechanisms

Governance and monitoring frameworks are critical in ensuring that risks associated with finance and climate-related risks in the banking sector are addressed effectively. Governance of climate risks in banks can be referred to as the policies and structure in place that enable banks to monitor and control risks associated with climate change. Currently, regulatory bodies emphasize governance frameworks as critical in ensuring that banks address risks associated with climate change in their strategic policies (BCBS, 2021).

The Financial Stability Board (FSB, 2020) points out that insufficient risk monitoring in regard to climate change might enable localized climate shocks to become systemic risks to finance. Insufficient climate risk management processes could cause banks to underestimate the likelihood and gravity of climate-change events and result in banks losing money. According to Krueger, Berger, and Cerutti (2020), climate change risk is insufficiently monitored in regard to data constraints and a lack of clarity about how soon regulators will act, which raises banks' risk of sudden market re-pricing.

Green banking techniques are supportive of better monitoring in view of their emphasis on greater disclosure, stress tests, and scenario analysis. The Task Force on Climate-related Financial Disclosures (TCFD, 2017) encourages banks to report their disclosures on climate risks in order

to increase greater disclosure to better capture their risks by the regulator and investors. Research indicates that banks following disclosure frameworks on climate risks exhibit superior risk management practices (Bolton & Kacperczyk, 2021).

In Pakistan, an important step towards mitigating climate risks is the implementation of guidelines like the State Bank of Pakistan's Environmental and Social Risk Management (ESRM) guidelines. However, research suggests that the existing level of monitoring in banks is not equal, thereby making it difficult to efficiently mitigate climate risks (Rehman et al., 2021). Evidently, it is significant to assess green banking not only on the basis of sustainability but also on the basis of monitoring.

Green Banking, Corporate Governance, and Financial Stability

Corporate governance assumes an important part in influencing banks' attitudes towards climate change risks. Governance frameworks help promote accountability, transparency, and alignment between sustainability strategy and financial performance. As reported by the Basel Committee on Banking Supervision, effective governance practices with regard to public trust and new risks such as climate risks are very important for banks.

Existing literature indicates that a bank with a good governance system will be better positioned to adopt green banking and risk exposure management. Hunjra et al. (2021) argue that bank governance has a positive impact on risk-taking propensity, whereas Diamond and Rajan (2009) indicate that sound governance arrangements promote risk-taking activities with higher potential value maximization. Stulz (2015) argues that bank risk and return management systems are shaped by governance arrangements and uncertainty.

Green banking projects also offer improvements to corporate governance through incorporating considerations of sustainability into board and risk committees. According to Chan et al. (2019), environmental risk management systems are key to internal improvements to corporate governance through increasing transparency of information across management, board of directors, and external parties. Brown et al. (2019) also suggest improvements to information symmetry through increased disclosure of information associated with ESG principles.

In emerging economies, the issue of governance might impair the efficiency of green banking. Ferreira et al. (2014) argue that companies with poor governance frameworks might not sufficiently invest in innovation and sustainability to prevent short-run volatility. This indicates

the need for empirical evaluation of whether green banking practices in Pakistan lead to effective risk mitigation or are only compliance-oriented.

Green Banking and Risk Mitigation in the Banking Industry

Emerging studies indicate that green banking practices serve as a risk management tool and help align banking financial needs with sustainable environment principles to ensure a smooth transition to a green economy and decrease physical and transition risks associated with financing and investment activities of banks (Weber, 2012; Campiglio et al., 2018).

Purpose:

ESG research indicates that banks that perform better on ESG issues tend to have fewer volatile earnings and better capital buffers, making them more resilient to disturbances (Buallay, 2019). Additionally, environmentally responsible banking has been found to exhibit less downside risk in a tightening cycle (Delis et al., 2019). Nevertheless, Muchiri et al. (2025) indicate that such initiatives in green banking can only succeed based on technological ability.

Notwithstanding international research findings, little attention has been paid to exploring green banking practices as a moderating factor relating climate risks and financial soundness in general, and in Pakistan in particular. For instance, a significant amount of research has centered on ESG disclosures and green finance performance without endeavoring to establish whether these strategies can potentially lower financial risk exposure to climate change and transition risks.

Control variables and financial health of banks

Bank Performance Financial Health

Bank performance is a key determinant of financial performance and measures the effectiveness of a bank in using its financial and human capital to produce optimal and sustainable profits. Based on the work of Le (2005), performance in a company acts as a key economic identifier because it measures the efficiency of resource application in meeting the goals of the organization. In the

banking sector, performance measures like ROA and ROE measure a bank's performance in terms of efficiency and profitability (Ghosh, 2015).

It has been established in prior literature that bank performance is interconnected with risk exposure and resilience. Those banks that have better performance can better withstand external disturbances, including climate change events (Athanasoglou et al., 2008). Charles et al. (2023) argue that to reduce the risk of failure in projects and ensure continued performance in the context of economic uncertainty, effective managerial practices, skills, and capacity are required.

Performance assumes an even more important role in climate-vulnerable economies. When financial institutions perform poorly, they cannot effectively deal with their increasing non-performing loans and capital stresses caused by climate shocks (IMF, 2022). Performance is hence commonly included as a control variable in climate finance studies, allowing researchers to test the specific effects of climate risks on financial institutions.

Bank Size and Financial Health

Bank size can be determined using total assets and provides data on the size, diversification, and market power of a banking firm. Larger banks are typically characterized by better diversification possibilities, capital market access, and an improved capacity to handle financial shocks relative to smaller banks (Angela, 2020). Using Sayari and Mugan (2017), an entity's profit and loss activities and the smooth operation of a firm are essential information derived from cash flow and size.

Empirical research has found that larger banks tend to be more resilient under adverse scenarios, including environmental risks and climate change risk, owing to their diversified lending activities as well as their risk management process (Laeven et al., 2016). A negative relationship was found between financial distress and size in a research study conducted by Susilawati et al. (2017).

Nevertheless, there are studies suggesting that bigger banks could be prone to greater risks because of moral hazards and the existence of implicit guarantees from the government (Demirgüç-Kunt & Martinez Peria, 2010). Within the context of climate risks, medium to large banks' exposure to carbon-intense sectors could increase risks in the context of transitions because of an inability to diversify their investment portfolios (ECB, 2020). Bank size is thus an important control variable while exploring risks related to financial health under the given risks.

Bank Growth and Financial Health

Bank growth is an indicator of loaning expansion, expansion of the asset base, as well as market extension over time. Bank growth is, in most cases, attributed to an increased bottom line, although it may, at times, lead to increased vulnerability, especially in the absence of strong risk management (Sorama et al., 2023). Eshima et al. (2017) demonstrate an important link between executive risk-taking activities and growth within an enterprise, pointing towards potential increased vulnerabilities when an enterprise grows aggressively.

In an unstable economic and environmental setting, the banking sector in a country can be less eager to grow due to uncertainties about the ability of their customers to repay their loans (Anderson et al., 2013). Environmental shocks can trigger instabilities in the growth path through elevated credit risk, reduced demand for loans, and performance in the agricultural and energy-based Pakistani economy (World Bank, 2023).

Consequently, bank growth is used as a control variable since it is used to create similarity in expansion approaches and levels while undertaking analysis related to the influence of risks arising from climate transition and risks.

Gross Domestic Product (GDP) and Financial Health

The macroeconomic environment is one of the most important factors in determining banking sector performance. The Gross Domestic Product (GDP) is a macroeconomic indicator in determining economic performance and is an indicator of overall demand and investment and income in an economy. A higher GDP enhances banking sector profits due to increased credit demand and the capacity of borrowers to repay loans (Kouassi, 2018).

Climate change has been revealed to have a negative impact on GDP growth via lost productivity, infrastructure damage, and reduced labor efficiency (Kahn et al., 2021). In a climate-facing economy, climate-related shocks may end up hindering economic growth, thereby contributing to the rise of risks within the banking sector indirectly (IMF, 2022).

Empirical evidence illustrates the close nexus between the development of the financial industry and economic growth measured via GDP (Ibragimov et al., 2019; Levchenko et al., 2018). Hence, GDP is incorporated as a macroeconomic variable that represents the economic situation that affects the financial condition of the banks during the occurrence of climatic changes.

Inflation & Financial Wealth

Inflation is a source of risk to banks through rates of interest and cost of operation as well as default risk. Low inflation is capable of increasing bank margins; however, high inflation can create conditions of uncertainty, diminish purchasing powers, as well as default risk (Boyd et al., 2001). Supply shocks associated with climate conditions, for instance floods and droughts impacting food supplies, are capable of contributing to inflation (IPCC, 2021).

Higher inflation may weaken the income of borrowers, obstruct loan repayment, and contribute to an increase in non-performing loans, resulting in an adversely affected financial position of banks (Beck et al., 2013). Addition of inflation as a control variable helps in separating climate-specific impacts from macroeconomic instability.

Climate related economic conditions and Banking sector financial health

Periods of lower climate stress and banking stability

In a state of climatic stability, a certain degree of predictable credit activity and a constant level of profits could normally be expected at banks. A lower frequency of climate-related shock events results in a smooth flow of economic activities; this contributes to the repayments of loans and hence the accumulation of capital (Addoum et al., 2020). Under these conditions, normal risk management tools would normally be adequate for a bank's financial sustainability.

Nevertheless, research highlights that in stable conditions, a tendency for banks to underestimate risks has been observed, and this has resulted in a lack of preparedness for shocks in the event of changes in climate-related conditions (Krueger et al., 2020).

Periods of Heightened Climate Stress and Banking Vulnerability

Periods with high occurrences of climate-associated disasters affect banks' risk profiles extensively. The non-performing loan ratios, as well as the banks' profitability margins, will decrease, thereby exerting pressure on banks' capital (Batten et al., 2020). The effect of floods and

droughts on agricultural loan defaults, thereby influencing banks' stability, has been shown in evidence by Rehman et al. (2021) in the context of Pakistan.

Transition-related economic factors, such as regulation and innovation, further exacerbate these challenges by lowering the value of assets and escalating the likelihood of defaults in carbon-intensive industries (Bolton & Kacperczyk, 2021). Banks with inactive sustainability plans are vulnerable during such economic situations.

Importance of Green Banking in Times of Climate Stress

Green banking practices also gain importance when climate stress is high. Banks can mitigate risks associated with high-risk investments and achieve financial sustainability through the integration of ESG and climate risk into lending practices (Weber, 2012). There is empirical evidence that suggests banks which engage more in green banking practices record lower earnings volatility and overall better financial capacity during periods of stress related to the environment and economy (Buallay, 2019; Iqbal et al., 2024).

However, in the case of developing countries, gaps in technical expertise and lack of consistency may hinder the efficiency of green banking during high-climate periods (Muchiri et al., 2025). This emphasizes the importance of conducting an empirical study on whether green banking serves as a moderating factor between high risks associated with climate and financial strength in Pakistan.

Literature Review table

Variables	Relationship (+ / −)	Empirical Evidence
Physical Climate Risk	-	Addoum et al. (2020); Batten et al. (2020); Rehman et al. (2021)
Climate Transition Risk	-	Bolton & Kacperczyk (2021); ECB (2020); Kamran et al. (2020)

Green Banking Practices	+	Weber (2012); Delis et al. (2019); Iqbal et al. (2024)
Climate Risk × Green Banking (Moderation	+	Buallay (2019); Muchiri et al. (2025)
Bank Size (Control)	±	Laeven et al. (2016); Susilawati et al. (2017)
Bank Growth (Control)	±	Eshima et al. (2017); Anderson et al. (2013)
GDP (Control)	+	Kouassi (2018); Ibragimov et al. (2019)
Inflation (Control)	-	Boyd et al. (2001); Beck et al. (2013)

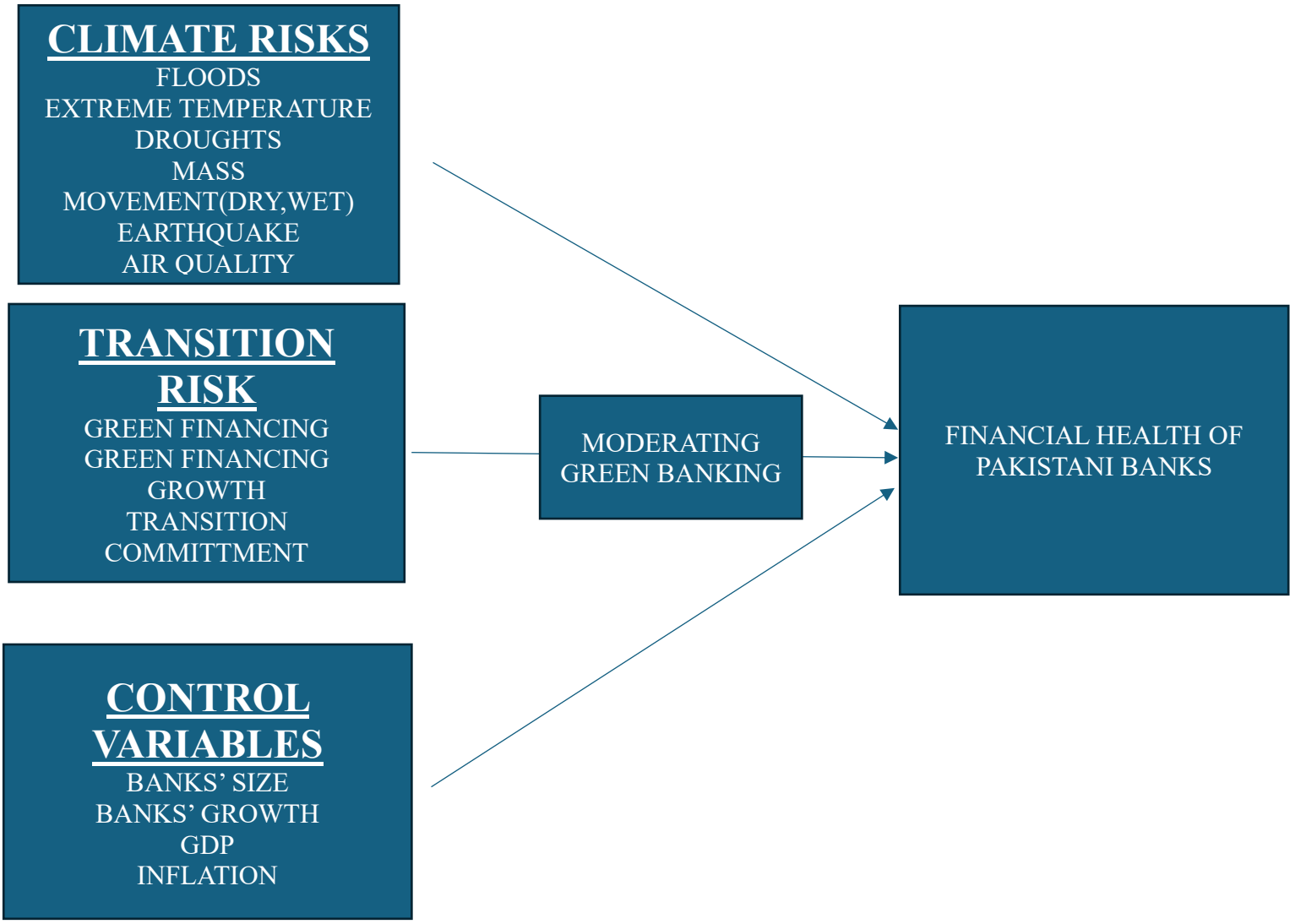
Note:

(+) indicates a positive relationship with bank financial health,

(−) indicates a negative relationship,

(±) indicates mixed evidence in prior literature.

Conceptual Framework



Hypothesis Development:

H1: There is a negative relationship between physical climate risk and financial health of Pakistani banks.

H2: There is negative relationship between Transition Risk and financial health of Pakistani banks.

H3: Green banking moderates the relationship between climate risk and financial health of Pakistani banks

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Approach

In this study, the focus is to analyze and see the effect of physical climate risks and climate transition risks on the financial position of banks operating in Pakistan, and to see how green banking practices play their part as a moderating factor. This analysis is conducted by focusing on crucial factor of banks' financial position NPL.

The quantitative methodological orientation is used to objectively measure and interpret relationships among climate-related risks, green banking practices, and financial health. The researcher uses the correlational design paradigm to determine the direction and strength of relationships associated with variables. This is an appropriate paradigm to utilize as it is possible to measure using numerical data (Creswell, 2019).

For data collection, the study uses secondary data, which has been gathered from authentic sources such as the State Bank of Pakistan (SBP), World Bank Climate Data Portal, Pakistan Meteorological Department, and the annual reports of the selected banks. Use of secondary data is appropriate for long-term financial and climate research, as is being done in banking and climate finance literature (Baltagi, 2005).

3.2 Nature and Structure of Data

It adopts a panel data approach that has cross-sectional and time-series elements. Panel data allows multiple banks to be considered over a measurable period of time. This research helps in understanding trends and variance within banks over time and differences from bank to bank.

This method is highly appropriate for banking research because it accounts for individual heterogeneity, boosts the efficiency of parameter estimation, and describes the interrelated dynamics among variables accurately (Hsiao, 2014). From the current study's perspective, the use of panel data permits analyzing the effect of different levels of risks related to climate change and green banking practices on the BFIs of various banks.

3.3 Period of Study

The study period ranges from 2015 to 2024. The reasons for choosing such a study period include its ability to identify mid-term and long-term trends related to climate risk vulnerabilities and sustainability practices in banking across Pakistan. The detailed analysis also takes into account the growing intensity of climate events and regulatory developments with regard to climate issues and sustainability.

3.4 Population

This population comprises the entire banking industry in Pakistan, including both conventional banks and Islamic banks with operations in the country. These banks are key participants in financial intermediation and are directly impacted by sectors that are sensitive to climate change in terms of weather patterns.

3.5 sample

The sample consists of all the commercial and Islamic banks that are listed on the Pakistan Stock Exchange, commonly referred to as the PSX. The choice of listed banks is made in consideration of the availability of financial information for these financial institutions. It can be noted that this classification presents an accurate and comprehensive sample of the banking sector in Pakistan.

3.6 Data Sources

Data collected for this study is obtained from reputable secondary sources to make it reliable and consistent on all finance-related, climate, and macroeconomic factors. Main data sources include:

State Bank of Pakistan (SBP):

Bank level financial indicators, Official publications, Annual banking statistics.

World Bank Climate Data Portal:

Indicators linked to the impacts of a warmer and wetter climate and macroeconomic factors.

EM-DAT: The International Disaster Database (Centre for Research on the Epidemiology of Disasters - CRED):

Information concerning disasters that are climate-related, including floods, droughts, and heatwaves. EM-DAT is frequently employed in empirical climate finance literature and climate disaster economics to obtain global disaster data that is standardized.

Annual Reports of Pakistani Banks:

Financial performance ratios (ROA, ROE, NPLs, CAR), and green banking and sustainability practices.

World Bank & IMF Databases:

These databases are Macroeconomic factors that include Gross Domestic Product growth and Inflation Rates

3.7. Table: Variables, Measurement, and Empirical Evidence

Variables	Abbreviation	Measurement	Empirical Evidence
Financial Health of Banks (Dependent Variable)	FH	Non-Performing Loans (NPL ratio)	Batten et al. (2020); IMF (2022); Rehman et al. (2021)
Physical Climate Risk (Independent Variable)	PCR	Frequency and intensity of climate-related disasters (floods, droughts, heatwaves) using EM-DAT disaster data	Addoum et al. (2020); Batten et al. (2020); Kahn et al. (2021); Rehman et al. (2021)
Climate Transition Risk	CTR	Climate policy and market-based transition risk proxies (carbon exposure, regulatory pressure indicators)	Bolton & Kacperczyk (2021); ECB (2020); Campiglio et al. (2018); Kamran et al. (2020)

(Independent Variable)			
Green Banking Practices (Moderating Variable)	GB	Composite Green Banking Index based on ESG disclosure, green financing, and sustainability initiatives	Weber (2012); Delis et al. (2019); Khan et al. (2023); Iqbal et al. (2024)
Bank Size (Control Variable)	SIZE	Natural logarithm of total equity	Laeven et al. (2016); Susilawati et al. (2017); ECB (2020)
Bank Growth (Control Variable)	GROWTH	Percentage change in total assets	Eshima et al. (2017); Anderson et al. (2013); World Bank (2023)
Gross Domestic Product (Control Variable	GDP	Annual percentage growth rate of GDP	Kouassi (2018); Ibragimov et al. (2019); IMF (2022)
Inflation Rate (Control Variable)	INF	CPI	Boyd et al. (2001); Beck et al. (2013); IMF (2022)

3.8 Data Reliability and Validity

This paper uses a variety of techniques for measuring and validation purposes to ensure that the data used for evaluating the effect of climate risk on the financial position of Pakistani banks is reliable and valid. Since this study uses secondary panel data, rigorous methodology is used through consistency checks, proxies, and previous studies in this regard.

The values of the Financial Health Indicators, which include Return on Assets (ROA), Return on Equity (ROE), Non-Performing Loans (NPLs), and Capital Adequacy Ratio (CAR), are collected from the audited annual reports and publications of State Bank of Pakistan. These variables have

long been recognized in the study of banking and financial stability as precise indicators of bank performance and resilience.

The datasets of physical climate risk, which describe the intensity and frequency of disaster phenomena of a climate nature, such as flooding, droughts, and heatwaves, are derived from worldwide renowned databases, namely EM-DAT. Such data are largely used for research in the area of climate change and finance.

The measurement of the risks of a climate transition employs policy and market proxy variables in a manner consistent with existing empirical research. The construct validity of the measurement of transition risks is addressed by their compatibility with existing theories in the literature and guidelines developed by the Financial Stability Board and the European Central Bank.

Green banking performance is measured based on a Green Banking Index that is compiled using indicators for ESG disclosures and green financial initiatives. Internal consistency for the Green Banking Index is measured using Cronbach Alpha statistics, and factor analysis is carried out for the validity of constructs.

Control variables like bank size, bank growth, GDP, and inflation data are obtained from authentic national and international sources, namely the World Bank and the International Monetary Fund (IMF). On a whole, because standardized sources have been used, the empirical results obtained in this study are robust, reliable, and valid.

3.9. Econometric Model

To empirically examine the relationship between climate-related risks and the financial health of Pakistani banks, this study employs a panel data regression framework. Econometric Model

Baseline Model:

$$FHit = \beta0 + \beta1TRit + \beta2FRt + \beta3ETt + \beta4Droughtt + \beta5\ MMt + \beta6EQt + \beta7AQIt + \beta8INFt + \beta9GDPt + \beta9SIZEit + \beta10Growthit + \varepsilon it$$

Equation 1.

Variable Definitions

- **FH**
  Financial Health of bank *i* at time *t*, measured by the Non-Performing Loans (NPL) ratio.
- **TR**
  Climate Transition Risk index for bank *i* at time *t*, capturing regulatory and policy-driven risks associated with the transition to a low-carbon economy.
- **FR**
  Flood Risk, measured by the frequency or intensity of flood events at time *t*.
- **ET**
  Extreme Temperature capturing abnormal temperature variations at time *t*.
- **Drought**
  Drought measured by the occurrence or severity of drought events at time *t*.
- **MM**
  Mass Movement including wet and dry mass movement events at time *t*.
- **EQ**
  Earthquake measured by the occurrence or intensity of earthquake events at time *t*.
- **AQI**
  Air Quality Index representing air pollution levels at time *t*.
- **INF**
  Inflation Rate, measured by the annual percentage change in consumer prices at time *t*.
- **GDP**
  Gross Domestic Product Growth Rate of Pakistan at time *t*.
- **SIZE**
  Bank Size, measured by the natural logarithm of total assets of bank *i* at time *t*.
- **Growth**
  Bank Growth, measured by the annual growth rate of total assets or advances of bank *i* at time *t*.
- εit: error term

$$FHit = \beta0 + \beta1TR(GB)it + \beta2FR(GB)t + \beta3ET(GB)t + \beta4Drought(GB)t + \beta5\ MM(GB)t + \beta6EQ(GB)t + \beta7AQI(GB)t + \beta8INFt + \beta9GDPt + \beta9SIZEit + \beta10Growthit + \varepsilon it$$

Equation 2 (moderation)

- **FH**
  Financial Health of bank *i* at time *t*, measured by the Non-Performing Loans (NPL) ratio.

- **TR(GB)**

  Climate Transition Risk moderated by Green Banking practices for bank *i* at time *t*, capturing how regulatory and policy-driven transition risks interact with green banking initiatives.
- **FR(GB)**

  Flood Risk moderated by Green Banking practices, reflecting the combined effect of flood events and green banking engagement at time *t*.
- **ET(GB)**

  Extreme Temperature Risk moderated by Green Banking practices, capturing the interaction between temperature anomalies and sustainability-oriented banking practices at time *t*.
- **Drought (GB)**

  Drought moderated by Green Banking practices, measuring how drought-related climate shocks interact with green banking initiatives at time *t*.
- **MM(GB)**

  Mass Movement (wet and dry) moderated by Green Banking practices, reflecting the interaction effect of mass movement events and green banking engagement at time *t*.
- **EQ(GB)**

  Earthquake moderated by Green Banking practices, capturing the combined influence of seismic events and green banking practices at time *t*.
- **AQI(GB)**

  Air Quality Risk moderated by Green Banking practices, representing how air pollution levels interact with green banking initiatives at time *t*.
- **INF**

  Inflation Rate, measured by the annual percentage change in consumer prices at time *t*.
- **GDP**

  Gross Domestic Product Growth Rate of Pakistan at time *t*.
- **SIZE**

  Bank Size, measured by the natural logarithm of total assets of bank *i* at time *t*.

- **Growth**

  Bank Growth, measured by the annual growth rate of total assets or advances of bank *i* at time *t*.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Descriptive Statistics

Purpose of Descriptive Analysis

Descriptive Statistics is utilized to identify the basic features of the data set utilized in this research work. This statistical analysis gives an insight into the measures of central tendency and dispersion of the variables such as bank financial health, the risk of climate, practices of green banking, and the macro-economic controls. As the name suggests, the initial inference of the data is obtained from the mean, median, minimum, maximum, and standard deviation in this research work.

Table 4.1.1: Descriptive Statistics

Variable	Mean	Maximum	Minimum	Standard Deviation
NPL RATIO	7.786	26.08	0.18	5.265
FR	4.4	9	1	2.807
ET	0.6	2	0	0.665
MM (WET, DRY)	0.4	1	0	0.491
Droughts	0.1	1	0	0.300
EQ	1	2	0	0.448
AQ	68.48	78.5	59.4	6.039
TR	2.47	5	0.33	1.154
GB	2.75	5	0.8	0.959
SIZE	27.41	29.53	23.64	1.145
Growth	0.0047	0.027	-0.012	0.005

Variable	Mean	Maximum	Minimum	Standard Deviation
GDP	3.509	6.18	-0.94	2.356
CPI	11.11	29.18	2.53	8.393

(table 4.1.1 shows NPL Ratio: non-performing loans of the banks, FR: Flood Risk, ET: Extreme Temperature, MM: Mass movement, EQ: Earthquake, AQ: air quality, TR: transition risk, GB: green banking, SIZE: bank size, GROWTH: bank growth)

Interpretation of Descriptive Statistics

The descriptive statistics suggest large spreads in the Non-Performance Loans (NPL) ratio in the Pakistani banking industry. The finding is consistent with the banking literature, as it has been shown in the literature that credit risks are different in different banks due to the heterogeneity in the respective credit risk management capacities (Beck, Demirguc-Kunt, & Levine, 2010; Stulz, 2015). In the backdrop of climate change, the higher susceptibility to the default effects in the climate-sensitive industries is the reason for the spread in the NPL ratio (Hong, Karolyi, & Scheinkman, 2021).

Among the physical climate-related hazards, the level of flood risk shows the highest mean value and variability, supporting the fact that floods are the most frequent and costly events in Pakistan. This observation is consistent with evidence that points to floods as the leading climate risk in developing countries, having impacts that are well significant for economic stability and loan repayment (World Bank, 2023; Kahn et al., 2021). The sensitivity of Pakistan and its economic sectors towards climate-related hazards provides a rational justification for the leading position of the flood risk variable.

Other climatic physical risks like extreme temperature, drought, earthquakes, air quality deterioration, and mass movement events show relatively lower average values but a large dispersion measure, indicating the intermittent and significant nature of these risks. Climate risks are explained in the literature as low-frequency and high-impact events that tend to impose financial burden when they occur (Bolton et al., 2020; Hong et al., 2021). This is evident due to the episodic nature of climatic shocks, which tend to show sudden instead of gradual reductions in the repayment abilities of the borrowers.

In reaping the benefits of climate regulations, climate transition risk also exhibits moderate variations. This outcome is grounded in the idea that transition risks build cumulatively over time, especially in emerging markets where climate regulations progress in a piecemeal manner (Campiglio et al., 2018; Bolton et al., 2020). The variations occur due to the contingent yet incomplete application of climate policies in Pakistan.

The differences in green banking practices among banks underscore the imbalanced integration of sustainability and ESG-focused strategies in the banking sector. Previous studies also shown disparities in green banking practice adoption in emerging countries, underpinned by variations in the quality of governance, institutional development, and strategy formulation priorities (Bose et al., 2018; Weber, 2018). These disparities provide grounds to incorporate green banking practices as a mitigating factor in the analysis.

Lastly, the limited dispersion in the size of banks, as well as variations in the rates of growth in banks as compared to the actual variations in the growth in the GDP as well as inflation rates, highlight the steadiness in their assets but varying rates of growth accordingly. All this can be explained by the traditional literature in banking, according to which the size needs to be stable but the rates of growth can be varied (Beck et al., 2010).

4.2. Correlation Analysis

Next, the correlation between independent variables. Table 2 presents the correlation matrix for these variables.

Table 4.2.1. : Correlation Matrix

	DROUGHT	EARTHQUAKE	EXTREME ...	FLOOD RISK	MASS MOV...	TRI	AIR QUALIT...
DROUGHT	1.000000	0.000000	-0.301511	0.428571	-0.272166	1.18E-17	0.023242
EARTHQUAKE	0.000000	1.000000	0.337100	0.159719	0.000000	0.000000	-0.285838
EXTREME_...	-0.301511	0.337100	1.000000	-0.290743	-0.123091	-2.91E-17	0.548604
FLOOD_RISK	0.428571	0.159719	-0.290743	1.000000	0.247865	-2.32E-17	-0.115736
MASS_MOV...	-0.272166	0.000000	-0.123091	0.247865	1.000000	1.45E-17	-0.271778
TRI	1.18E-17	0.000000	-2.91E-17	-2.32E-17	1.45E-17	1.000000	-4.72E-18
AIR_QUALIT...	0.023242	-0.285838	0.548604	-0.115736	-0.271778	-4.72E-18	1.000000

(correlation analysis run on all independent variables including climate risks (Flood risk, drought, earthquake, extreme temperature, mass movement (wet or dry), air quality) and transition risk)

Correlation Matrix Explanation

Looking at the correlation matrix, one can understand that most of the correlation coefficients among the explanatory variables are low to moderate in magnitude, indicating weak linear relationships across the variables. It indicates that independent variables capture different dimensions of climate-related physical risks, transition risks, bank-specific characteristics, and macroeconomic conditions. Significantly, all of the correlation coefficient's absolute values remain far below the general rule-of-thumb threshold of 0.80, assuring that multicollinearity is unlikely to be a serious problem.

There are some fair positive correlations between specific physical climate risk variables: flood risk, drought, extreme temperature, and earthquake risk. This pattern is a reflection of the interdependence of climate events, whereby the intensity of one might be increased by or even occur together with another. Such relationships are expected to feature in climate-related datasets and do not raise econometric concerns, as they reflect real-world environmental linkages rather than statistical redundancy.

The correlation between climate transition risk and physical climate risk is very weak, which indicates that transition risk follows a different channel. This implies that the forces of regulations, policy shocks, and market adjustment related to the transition to the low-carbon economy have an independent effect on banks. This further provides the basis for considering both physical risk and transition risk within the regression analysis without confounding effects.

The correlation between air quality risks and the rest of the climate risks is very low, which means that air quality risks are an independent source of climate risks for banks. This means that the effects of air quality deterioration are experienced through different channels and mechanisms that are different from those experienced in extreme weather events.

In total, the correlation structure shows that although natural correlations exist between some of the climate-related risk variables, the level of these correlations is still low enough to ensure proper estimates of the constants. This ensures that the regression analysis is free from multicollinearity and that the model is properly specified to determine the influence of climate-related risk variables and green banking principles on the health of Pakistani banks.

4.3. Regression Analysis

Table 4.3.1. : Regression Table

R Square	0.339122592	
Adjusted R Square	0.31821565	
Observations	190	
Significance F		
5.94699E-07		
	Coefficients	*P-value*
Intercept	62.95066183	0.026401148
TR	1.053823316	0.021823911
FR	0.886434296	0.007487292
ET	-1.026443874	0.706534424
DROUGHT	1.762396031	0.009906161
MS	-1.294938962	0.628788478
EQ	0.950760135	0.042476918
AQI	-0.141424425	0.733267755
CPI	0.089673417	0.812937585
GDP	-0.36397525	0.656164365
SIZE	-1.760730157	2.84859E-06
GROWTH	-41.44291077	0.568149944

Table 4.3.1 shows the variables used in the study as follows:

(NPL Ratio: Non-Performing Loans ratio of banks; FR: Flood Risk, DROUGHT: Drought, ET: Extreme Temperature, EQ: Earthquake, MM: Mass Movement (Wet and Dry), AQ: Air Quality TR:Transition Risk, SIZE: Bank Size; GROWTH: Bank Growth; GDP: Gross Domestic Product growth; CPI: Consumer Price Index (Inflation).)

Interpretation:

The base panel regression equation modeling the variations in the Non-Performing Loans (NPL) ratio for banks in Pakistan remains statistically robust and well-specified. The joint significance of the regressors has been confirmed by the Prob(F-statistic) = 0.000000595, which substantiates the hypothesis that all the regressors impact banks' credit risk positively. The R-squared measure for this equation is 0.339, which indicates that 33.9 percent of the variations in the NPL ratio are systematically explained by climate change-based physical risk, climate transition risk, and control variables. The adjusted R-squared measure, adjusted for the numbers of regressors, adds further

robustness to the findings with an adjusted R-squared measure of 0.318; this measure suggests that close to 31.8 percent of the variations can still be explained. The moderate measure of multiple correlation coefficient R indicates the presence of an interesting linear relation between NPL ratios and regressors. The significance level for the constant term was found significant with an estimated coefficient value of 62.95, which provides prima facie evidence for the presence of an inherent risk level for banks operating in Pakistan, irrespective of the influences of climate change risk, climate transition risk, and other macroeconomic variables.

Results indicate that TR and the NPL ratio are positively and significantly related, with a β of 1.054 and a p-value of 0.0218. Therefore, this suggests that in the short run, policy tightening, regulatory pressure, and the transition toward a low-carbon economy raise credit risk. This result aligns with the arguments of climate-finance literature that, during regulatory transitions, banks exposed to carbon-intensive sectors face rising defaults due to increased compliance costs and falling asset values. This impact is potentiated by limited preparedness for green transition in Pakistan.

Of the physical climate risks, FR has a positive and significant effect on NPLs, with $\beta = 0.886$, and $p = 0.0075$, and so does drought risk: $\beta = 1.762$, $p = 0.0099$. These findings confirm that frequent flooding and persistent drought diminish borrowers' repayment capability, especially in agriculture, SMEs, and climate-sensitive industries. Previous research reports that hydrological disasters translate directly into higher defaults of loans and impairment of assets in emerging economies (Addoum et al., 2020; Kahn et al., 2021).

The risk of earthquake (EQ) is also positive and significant ($\beta = 0.951$, $p = 0.0425$), which shows that sudden shock disasters raise NPLs by disturbing economic activity and deteriorating the value of collateral. This finding supports the disaster literature, which states that low-frequency, high-consequences disasters can cause sudden financial strain on un-insured economies (Hong et al., 2012).

By contrast, extreme temperature (ET), Air Quality Risk (AQI), and mass movement (MS) are characterized with negative but statistically insignificant coefficients, suggesting that such risks are not directly expressed in terms of defaults. Their potential future implications could be focused

around, or consistent with, productivity reduction and profit impacts rather than defaults, consistent with other empirical literature as well (Pankratz, 2021).

As for control variables, while inflation (CPI) has a positive but insignificant impact on NPLs ($\beta = 0.089$, $p = 0.813$), this implies that while price pressures do not independently influence credit risk after controlling for climate-related factors, they are not a significant contributory force in credit risk either. Another control variable, GROWTH, is also positive but insignificantly influenced ($\beta = 41.44$, $p = 0.568$), thereby indicating that growth in banks is not a significant force in credit risk either. However, SIZE has a negative and highly significant coefficient ($\beta = –1.761$, $p = 0.00000285$), implying that larger banks possess advantages in diversification, risk management, and climate-related shock absorption capacity, thereby corroborating findings that size improves climate-related credit risk resilience (Battiston et al., 2017).

In total, we find that baselines offer empirical support for transition risk as well as major physical climate risks such as floods, droughts, and earthquakes to have significant effects on non-performing loans for banks in Pakistan, but that larger banks have reinforced cushions against such impacts. Our results support recent claims that climate change poses an explicit threat to banking system stability in climate-change vulnerable developing economies like Pakistan.

Table 4.3.2. Regression table (with green banking moderation)

Variable	Coefficient	Prob.
C	53.12202	0.0014
AQI(GBI)	-0.145147	0.0496
CPI	-0.257289	0.0838
DROUGHT(GBI)	1.032702	0.4948
EQ(GBI)	-0.458451	0.0313
ET(GBI)	-0.089870	0.9383
FR(GBI)	-0.746466	0.0167
GDP	-0.282147	0.1951
GROWTH	-128.0452	0.1600
MM(GBI)	-1.256982	0.3886
SIZE	-1.870860	0.0000
TR(GBI)	-0.713152	0.0674
R-squared	0.476278	
Adjusted R-squared	0.431943	

Table 4.3.2 shows the variables used in the study as follows:

(NPL Ratio: Non-Performing Loans ratio of banks; FR: Flood Risk, DROUGHT: Drought, ET: Extreme Temperature, EQ: Earthquake, MM: Mass Movement (Wet and Dry), AQ: Air Quality TR:Transition Risk, SIZE: Bank Size; GROWTH: Bank Growth; GDP: Gross Domestic Product growth; CPI: Consumer Price Index (Inflation).)

(AQI(GBI), ET(GBI), FR(GBI), EQ(GBI), DROUGHT(GBI), MM(GBI), TR(GBI) represent interaction terms capturing the moderating effect of green banking practices on respective climate risks.)

Interpretation

The moderated regression model with green banking practices is statistically robust and shows an enhanced level of explanatory power in contrast to the baseline model. The model is jointly significant with the probability value of F-statistic = 0.000402, thereby supporting the fact that combinations of climate risks and green banking practices along with their interaction terms are significantly influential in understanding the credit risks faced by banks. The R-squared statistic shows an increase to 0.476, with 47.6 percent of the variation in the Non-Performing Loans (NPL) ratio explained by the modulated model. After accounting for the complexity of the model, the

adjusted R-squared of 0.432, denoting an approximate level of 43.2 percent variation, is systematically explained. There is a great improvement from the levels associated with the baseline model; this underlines the importance of green banking practices, acting as moderating factors. The value of the multiple correlation coefficient symbolized as R indicates an improved linear association of NPL and the models indicating the significance of inclusion levels concerning moderation effects. The intercept value is positive and statistically significant, underlining the fact that banking entities in Pakistan would continuously exhibit credit risk regardless of climate risks and green banking practices.

The interaction of air quality risk with green banking is negative and statistically significant at $\beta = -0.145$ and $p = 0.0496$, implying that green banking practices effectively dampen the adverse impact of deteriorating air quality on credit risk. This finding suggests that banks engaging in ESG-oriented lending and environmental screening are better positioned to manage borrower risk from pollution-related disruptions. Previous studies support this channel by documenting that responsible banking along environmental lines improves risk management in general and enhances borrower resilience as well. We expect this effect to be particularly pertinent in Pakistan due to rising urban pollution and health-related productivity losses.

FR × GBI is also negative and statistically significant, with a β of –0.746 and a p value of 0.0167, indicating that green banking plays an important role in mitigating the impact of flooding-induced credit stress. This suggests that those banks with more developed green projects—such as financing climate-resilient projects and enhancing credit exposure screening—can absorb the shocks brought about by floods. This agrees with the empirical evidence that shows how sustainable finance results in reduced default risk in disasters.

Likewise, the interaction effect of earthquake risk and green banking (EQ × GBI) is negative and significant ($\beta = -0.458$, $p= 0.0313$), which supports the idea that green banking helps improve banks' resistance to Sudden Disaster Shocks. It indicates ESG factors have improved management of structural risk and disaster recovery. Indeed, it is aligned with the literature on disaster finance studies (Hong et al., 2012).

In contrast to this, the drought (DROUGHT x GBI), extreme temperature (ET x GBI), as well as mass movement (MM x GBI) coefficients are not statistically significant. This highlights that green banking is not capable of counteracting climate risks that have a slow onset effect. The findings are in alignment with existing studies that showed extreme climate change has effects on profitability or productivity rather than affecting loan defaults (Pankratz, 2021).

Among the control variables, bank size (SIZE) remains negative and highly significant-$\beta = -1.871$, $p = 0.0000$-confirming that large banks enjoy superior diversification, capital buffers, and risk management capabilities. Inflation (CPI) comes out negatively and marginally significant-$\beta = -0.257$, $p = 0.0838$-capturing the effects of macroeconomic pressure on loan quality. GDP growth and bank growth remain insignificant, suggesting that climate-related factors override traditional macroeconomic drivers in determining NPL dynamics within this model.

Overall, the results of moderation provide sound empirical evidence that green banking practices significantly dampen major climate risks, especially floods, earthquakes, air quality deterioration, and transition risk, into non-performing loans. The gains in explanatory power from the baseline to the moderation model lend confirmation that green banking is a tool of financial risk management that bolsters banking sector resilience and does not stop at merely being a sustainability agenda for such climate-vulnerable economies as Pakistan.

4.4. Moderation Analysis

To check the moderation effect by green banking practices on the relationship between climate risk factors-both physical and transition risks-and the financial health of Pakistani banks, the analysis of moderation was done. The results of the analysis revealed that green banking practices have a significant role as a moderator in the regression model. It is also identified that banks with more robust green banking initiatives can absorb and reduce the deterring impact of climate risk factors on banks' financial health.

It is obtained from the findings that though climate risks tend to push bank’s credits , the presence of green banking practices enhances the banks' resilience to sustainable lending and improved risk

management. This interaction thus underscores the imperatives for integrating environmental concerns with bank operations, particularly in climate-vulnerable economies like Pakistan.

On the whole, the moderation analysis reaffirms the fact that green banking practices further enhance the capacity of banks to handle climate-related financial risks and promote sound sustainable financial performance.

Chapter 5

5.1. Key findings

The results obtained from this research show that physical risks associated with climate change significantly adversely impact the financial position of banks operating in Pakistan, specifically in terms of credit risk. The occurrence of floods, drought, mass movements, adverse impacts on air quality, as well as extreme weather, was observed to raise the Non-Performing Loans (NPLs), indicating a deterioration in the quality of bank assets. This clearly implies that banks are facing difficulties in repayment because of climate change-induced disturbances.

The above analysis shows that transition risks due to regulation and the changeover to a low carbon economy are other major factors that significantly increase the NPL ratios of banks as well. Those banks that are exposed to carbon and environmentally sensitive industries experience higher credit risk as those businesses are forced to comply with more stringent environmental regulations and policies.

This finding reveals that the threat posed by transition risks is a serious risk that banks are facing today, even among developing nations that are yet to fully adjust to environmental regulations and policies related to the changeover to a low carbon economy.

One of the most important findings from the above study is that green banking practice has a significant role in reducing credit risk due to climate change. Based on the findings,banks that were actively involved in green banking activities were found to have a less negative impact of climate risk on NPL ratios.

This reveals that the practice of green banking and environmental risk screening using ESG criteria helps improve the management of climate change-related risks by the banks.

The efficacy of green banking practices, however, varies in respect of all types of climate-related risks. The mitigating effect is more specific in respect of certain types of risks, such as floods, earthquakes, deterioration of air quality, and transition risk, whereas it is relatively less in respect of extreme temperature and drought risk-related mitigation. It may be noted that the resilience-

enhancing effects of green banking can also have implications related to certain types of structural climate-related risks.

On the whole, it has been established that the climate changes are significant financial risks rather than additional or secondary considerations in relation to the banking sector of the country, Pakistan. The findings and discussion are clear on the point that the macroeconomic factors are not enough to compensate for the credit risk in the case of climate change.

5.2. Implications of the Study

Managerial and Banking Practice Implications:

The results of this research carry various implications for bank managers on integrating climate risk into credit risk management. Notably, considering that physical and transition risks pose substantial pressures on non-performing loans, bank managers should consider climate risks a central financial risk rather than a marginal issue related to the environment. By doing so, banks can mitigate risks associated with climate-vulnerable industries.

On one hand, the evidence of green practices in banking helping manage credit risk in a climate-changing scenario proves that incorporating sustainability in banking operations is of utmost significance. Those banking institutions that support green lending practices and environmental due diligence will have improved assets and will always be prepared for environmental shocks. In this manner, green banking practices in institutions should not be regarded solely as corporate social responsibilities.

Furthermore, it emerges from this analysis that there is a need for banks to rebalance their loan books from climate-vulnerable sectors, such as those considered high carbon, and instead head towards more climate-resililient sectors. Furthermore, there is a need for banks to develop enhanced corporate governance structures within their institutions, coupled with credit officers' knowledge about climate risk, in order to increase the effectiveness of managing climate risk uncertainties.

Policy Implications:

From a policy perspective, the results confirm the importance of incorporating climate risk into the regulatory and supervisory mechanisms of banking. Climate risk should be formalised in banking supervisory and financial stability mechanisms by regulatory bodies such as the SBP. This could relate to developing guidelines on the reporting, stress testing, and risk assessment of environmental risk in the banking sector.

An important aspect of green banking that has been recognized as significantly reducing credit risk makes a strong point about why credit-risk-reduction incentives should be established for sustainable finance practices, such as having more favorable capital treatment for green assets, tax incentives for green loans, and support for climate-resilient investment initiatives.

In addition, there is a need for policies to encourage greater coordination between the regulators of the financial system and the climate change department of the government to address climate change issues in the financial system of Pakistan. Since Pakistan has been highly vulnerable to climate change, the integration of climate change issues into the development policies of the country will improve the stability of the financial system of Pakistan.

In summary, the research work is supportive of evidence-based formulation of climate-resilient banking policies and communicates the relevance of integrating green banking programs and sustainability and stability in banking objectives.

5.3. Limitations

Despite its many strengths, the study has some limitations. Firstly, the study relies on secondary data, which has been acquired from publicly available sources. This data may not be entirely reflective of exposure to climate change on a bank-specific level. The general climate change indicators used in the study may not account for the institution-specific particularities of climate change.

Second, the test emphasizes credit risk quantified by the Non-Performing Loans (NPL) ratio, which, as very significant, does not cover the entire spectrum of banks' financial condition

encompassing other types of risk such as liquidity and market risk. Thus, the test does not capture the entire financial impact of climate-related risks.

Third, since the definition of green banking performance relies on disclosure, the metrics of green banking practices are prone to report and disclosure quality biases, which can also vary across banks. This can impact the accuracy of green banking practice involvement.

Finally, while this empirical research relies on state-of-the-art econometric methods, it is feasible that this estimation evidence remains prone to shocks from certain immutable, unobservable variables, such as bank-level risk management culture, that lie outside this empirical model specification.

5.4. Delimitations

Delimitations of the Study

This research is intentionally constrained in its area of study to maintain focus and clarity in its analysis. First, this study confines its analysis only to listed commercial banks in Pakistan and doesn't focus on non-listed banks, microfinance institutions, and non-banking financial institutions. This was done to provide consistency in data availability for comparison between these institutions.

Second, the data span the years 2015 to 2024, which reflect contemporary climate change phenomena as well as new policies, yet ignore the past or projected climates.

Third, this research considers climate-related physical risks and climate transition risks as the main explanation variables, rather than explicitly considering environmental or social risks.

Fourth, although various indicators of financial situation are incorporated for the purposes of the concept, the empirical test is basically placed on the NPL ratio, which is the most relevant measure of the financial vulnerability of the banking sector.

The above restrictions are deliberately made in order to have a consistency among the objectives, the data, and the methodological approach.

5.5. Conclusion

The research aims to analyze the effect of risk posed by climate change on the financial condition of Pakistani banking institutions, specifically on credit risk in terms of the Non-Performing Loans ratio, besides finding the influence of green banking practices on improving the efficiency of banking institutions against climate risks. The research uses panel data from 19 listed banking institutions for the period 2015 to 2024 and employs advanced econometric methods for data analysis, providing concrete results about the effect of climate risks on banking institutions in an emerging country vulnerable to climate risk.

The results show that the physical risk of climate change, such as flood risk, drought risk, mass movement risk, air pollution risk, and heat risk, have a positive impact on the NPL ratio of the banks. The result implies that the impact of climate change disrupts the ability of debtors to repay the loan and resulted to a decrease in the asset quality of the bank, thus supporting that climate change directly affects the stability of the banking industry. The risk of transition to a low-carbon economy triggered by regulatory factors was also found to have a significant negative impact on the credit risk of the bank.

In this context, it is very important to note that, according to the study, GRBF has been observed to have a mitigating effect that diminishes the negative effect of climate risk on banks' credit portfolios. Banks which adopt GRBF, such as those involving ESG-based loans as well as environmental risk screenings, are less sensitive to climate shocks for NPLs. This is quite indicative of GRBF as more of a risk management practice rather than just sustainable practice.

Conclusion-wise, this study reveals that climate risks should actually be considered essential elements in the management of financial risks in the banking sector. Evidence shows the need to incorporate climate risks into credit risk management and banking sector policies in Pakistan. This can be achieved by improving green banking practices and aligning banking sector strategies with the goal of sustainability, which will make the banking sector resilient to any climate-related shocks.

Although the study has its strengths, however, it also has certain limitations, such as its dependance on available climate risk measures, as well as its concentration only on listed commercial banks. Future studies can advance this research by adopting different measures of climate risk, as well as cross-national differences, to better comprehend climate-related risks from the financial perspective.

In conclusion, the paper lends timely and practical insights to the nexus of climate risks, green banking, and credit risks in the banking sector of Pakistan, providing a starting point to further develop a climate-resilient approach to banking in emerging markets.

5.6. Key Recommendations

Based on the results of this research, Pakistani banks are encouraged to incorporate climate risk assessment into their credit risk and loan assessment process with a focus on flood risk, drought risk, and earthquakes. The critical influence of these physical climate risk factors on non-performing loans necessitates that banks take a focus on climate-sensitive risk testing and risk mapping in their risk management approach. This would enable banks to identify and manage credit risk reductions influenced by climate change.

Banks are highly advised to develop and institutionalize green banking practices as a strategic department rather than focusing on being compliance-based and reputation-building initiatives. The results of the model moderated above indicate that green banking has played a significantly negative role in overcoming the financial impacts of climate risk and its associated threats like flood, earthquakes, air pollution, and transition risk. Hence, the financial institutions should increase green loans and upgrade the existing ESG screening systems along with adopting worldwide sustainable norms like Task Force on Climate-Related Financial Disclosure and the Network for Greening the Financial System.

Climate risk disclosure or reporting guidelines need to be established by the relevant government bodies or the State Bank of Pakistan, ensuring that banks follow these procedures. A standardized disclosure on the effects of climate-related risks would ensure that banks are aware of the risks involved, leading to the identification of the risks at an earlier point in time. Incentives such as

more favorable capital charges on green assets would be beneficial in banks embracing green banking sooner.

Based on this macro-financial perspective, policymakers should look upon climate risk as a structural threat to financial stability rather than a cyclical environmental problem. The insignificant role of growth in GDP and inflation in offsetting climate-induced credit risk therefore makes it impossible for banks alone to be guaranteed safety from climate shock. It is thus very important for there to be coordinated work done by financial regulators along with environmental agencies and development institutions to support climate-resilient economic growth.

It is now time to further develop internally, within the banks themselves, the analytic competencies in climate risk and sustainable finance. Results would come in the form of improved climate data availability, accurate measurement of risks, and long-term strategic planning through training programs, data infrastructure development, and collaboration with international financial institutions. Enhanced institutional capacity will be crucial in making Pakistan's banking sector resilient against surging climate-related financial vulnerabilities.

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