The Nexus Between Climate Risk and Financial Performance of Selected Universal Banks on Ghana Stock Exchange

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ABSTRACT

Climate risk and its implications for financial institutions have become increasingly significant in the global discourse. This study focuses on the nexus between climate risk and bank financial performance, with a specific emphasis on licensed universal banks in Ghana. The study covered fifteen (15) years, from 2010 to 2024. Based on the data availability and convenience, the study was restricted to ten (10) banks. Panel data regression technique was used to establish the causal relationship between the variables. Specifically, study used the Generalized Least Square Regression method to control the effects of autocorrelation and heteroskedasticity present in panel data. The study also employed Principal Component Analysis (PCA) to derived Financial Performance Index. From the Hausman Specification test, the null hypothesis were rejected for model since the p- .values of the chi-square was less than 0.05. This implies that the fixed effects model was more appropriate for the model. The results showed that climate risk has a significant negative impact on financial performance of selected licensed universal banks in Ghana. This implies that climate risk significantly reduces the bank financial performance of the selected commercial banks.

Keywords: *Climate Risk, Bank Performance, Principal Component Analysis, Financial Performance Index*

1.0 Introduction

Climate change is rapidly being recognized as a major danger to global economic growth and financial stability (Dafermos, Nikolaidi and Galanis, 2018; Lee et al., 2022). Climate change is a projected major change in worldwide weather patterns that is attributed to elevated levels of greenhouse gas emissions caused by human activities (IPPC, 2014). The predicted impacts of climate change are becoming increasingly visible. Climate change brings about environment and climate-related risks (Asante et al., 2015). These risks include severe weather events, water shortages, and the failure to respond to and ameliorate the consequences of climate change. It is becoming more apparent to policymakers, scholars, and the general public that there is an urgent need to address climate-related security concerns via collaboration and dialog.

Practically every industry in the economy is exposed to hazards arising from the immediate and prolonged physical impacts of climate change. The entire business value chain is impacted by climate risk, from primary materials to final consumers. In addition to inadequate adaptation capabilities, the current state of climate risk exposes the economies and societies of a number of countries to the direct and indirect negative effects of climate change and climate-related disasters. Recent research indicates that climate risk can impact both overall economic indicators and the operations and qualities of companies through two main channels: (i) physical channels, which involve direct physical harm caused by climate-related events; and (ii) transition channels, which encompass the disruptions associated with transitioning to a less environmentally damaging economy (Lee et al., 2022). In research undertaken by Dietz et al. (2016), the aim was to measure the impact of climate change on the worldwide financial system. Based on their research, climate change might potentially decrease the dividend payments of businesses, thereby impacting the value of financial assets.

The present scientific understanding of climate change provides solid evidence on climate risk, or the potential adverse consequences of climate change on society as a whole in the decades to come (Roncoroni et al, 2021). In contrast, asset prices do not presently represent such scientific understanding. One set of explanations for this state of things concerns financial markets' failure to absorb externalities (Stiglitz et al., 2017; Stiglitz, 2019), particularly over time horizons longer than a few years. Climate change and climate-related risk are projected to have serious consequences for stability of the financial sector, notably in banking (Scott et al., 2017). Climate risks could influence the safety of the banking industry via transitional risks like uncertainty around the change towards a low-carbon economy, as well as physical risks like severe weather occurrences. Over years, banks have had to closely monitor how extreme weather occurrences affect their ability to continue operations. According to Jack et al. (2021), climate risk is a systemic problem with broad implications for the world economy, health, security, and prosperity. Mitigating climate danger will need a coordinated worldwide effort to carry out systematic alterations, and multiple questions exist about the optimal configuration of this effort.

In 2020, the United Nations Climate Change published an article stating that robust and high-quality institutions are essential for sustainable development as well as successful and sustained climate mitigation and adaptation. In order to prevent corruption from undermining the fight against climate change, institutions need to coordinate their anti-corruption efforts. Transparency International claims that although the climate is not a sector, it involves corrupt major industries, including waste management, forestry, energy, and construction. Corruption adds at least twenty percent to the expenses of these industries.

1.1 Problem Statement

According to the 2017 Country Climate and Development Report (CCDR) for Ghana that was published by the World Bank Group, if immediate efforts are not done regarding climate change in Ghana, at least one million people might fall into poverty as a result of climatic shocks. It is estimated that by 2050, low-income families may see a drop in income of up to forty percent. Universal banks fund a substantial number of projects in Ghana, as they do in many other developing nations. Universal banks also provide finance for activities that have a negative influence on environmental quality and social standards. For example, activities like as mining, forestry, and cocoa-induced agricultural development have resulted in a decline in total forest cover from 32.7% in 1990 to 21.7% in 2010. The Network for Greening the Financial System (NGFS), which was founded in December 2017, recognized that climate change risks were a source of financial risk and might have a negative impact on the banking system's overall performance. As a result, central banks and regulators are responsible for ensuring that the financial system is resilient to the risks associated with climate change.

Physical hazards can manifest in various ways for financial institutions, including direct and indirect consequences. These consequences may arise from the institutions' exposure to companies and households that are impacted by climate disruptions, as well as from the repercussions of climate change on the wider economy and the feedback mechanisms that occur within the financial system (Zhang, Zhang, & Lu, 2022). Financial institutions may be impacted by the consequences of climate change on their operations and personnel, supply chain, distribution chain, consumers, tangible assets, and the communities on which they depend. While some consequences will be immediate, such as the destruction of property caused by floods, others will have a longer-lasting effect, like reduced water supply as a result of heightened demand from other regions. Climate-related risks have the potential to impact borrowers' capacity to completely amortize their bank debts, either directly or indirectly. This, in turn, can elevate the probability of default (Buhr et al., 2018; Dowla, 2018). Furthermore, the potential deterioration of collateralized assets may exacerbate credit risks, which may have adverse consequences on the profitability of the financial institutions.

Despite the existence of empirical evidence demonstrating the influence of climate risk on microeconomic and macroeconomic systems, there has been a lack of research pertaining to relationship between climate risk and bank performance in Ghana and Africa as a whole (Zhang et al., 2021). In order to address this empirical void, the present study examines the relationship between climate risk and financial performance licensed commercial banks in Ghana. Financial institutions generate liquidity through the conversion of illiquid assets into liquid assets and deposits into assets (Berger and Bouwmann, 2009). This research posits that climate risk can affect banks' overall liquidity creation by influencing the demand and supply aspects of liquidity creation via its effects on the economy and various economic sectors. Motivated by this, the research covers this empirical void by investigating whether climate risk can influence banks' liquidity creation in Ghanaian context.

Limited number of scholars have employed exhaustive indicators in their efforts to quantify the impacts of climate risks (Song, Wang, and Wang 2023; Huang et al., 2018). This study provides a scholarly contribution by drawing upon the works of Huang et al. (2018) and Song, Wang, and Wang (2023), employing the global climate risk index (CRI) as a measure of climate risks and its influence on the performance of banks. In contrast to individual climate indicators like temperature, precipitation, floods and landslides, the Climate Risk Index (CRI) gives a complete assessment of severe weather-related losses fatalities on a country-by-country basis. This metric measures the vulnerability and risk of each nation to extreme weather occurrences, for example, hurricanes, droughts, and heatwaves.

1.3 Study Hypotheses

H0: Climate risk has a significant negative impact on financial performance of licensed universal banks in Ghana.

2.0 Literature Review

This section reviews briefly significant concepts, theories and empirical literature by various researchers relating to climate risk, institutional quality and bank performance.

2.1 Concepts Review

2.1.1 Climate Change and Climate Risk

A climate change is an unusual variation in the weather. This might be a variation in the amount of precipitation that a place receives on a yearly average, or it could be a variation in the temperature that a place experiences on a monthly or seasonal basis (NASA Educational Technology Services, 2018). Social, economic and cultural behaviours are both directly and indirectly impacted by climate change, which has a significant impact on both nature and human activity. According to Maier, Whitehead, and Walter (2018), climate risk is the possibility that a hazardous weather event and its consequences would have an impact on a certain system and the system's vulnerability to those consequences. Addressing climate change and psychology education: An approach to taking action. The possibility that climate change may have a negative impact on natural or human systems is known as climate risk, according to the Intergovernmental Panel on Climate Change (IPPC). It is crucial to comprehend and anticipate how climate change risks may affect economic activity as long as global temperatures are predicted to increase (Dell, Jones, & Olken, 2014). Extreme weather events have a direct impact on businesses including mining, forestry, fisheries, and agriculture since these sectors are susceptible to climate change. Because the market may connect all sectors, industries like banking that rely less on the environment are equally impacted by climate change (Sun et al., 2020).

2.1.2 Categories of Climate Risks

The literature on climate risk classifies climate risks into two parts (Lee et al. 2022). The first strand of literature makes the claim that climate risk directly harms society and the economy via physical channels, known as physical risks. Physical risks are risks related to physical changes brought on by climate changes. The US

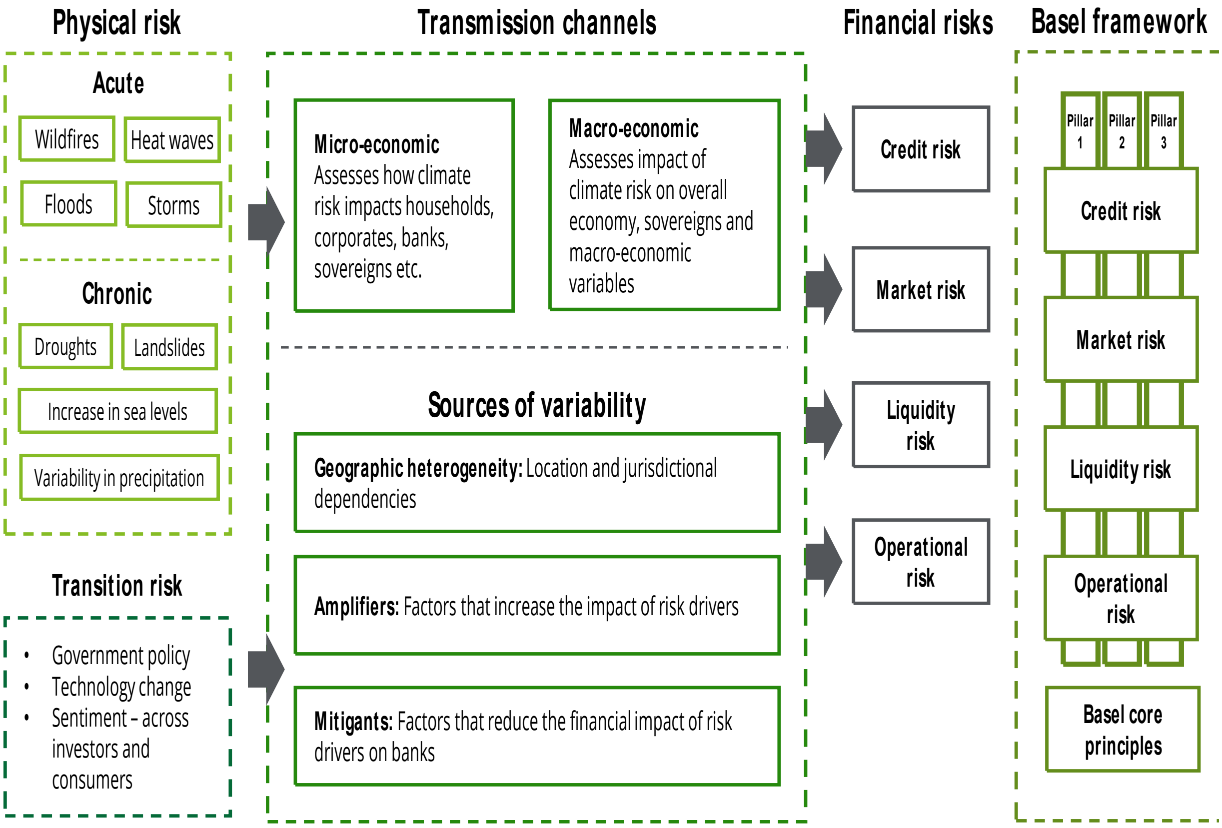
Environmental Protection Agency claims these risks may be either acute or chronic physical risks. According to Mazmanian, Jurewitz & Nelson (2020), acute physical risks are defined as those that are triggered by specific occurrences, such as heightened intensity of severe weather events like hurricanes, cyclones, heat waves, or floods. Acute physical risks might result in lower income from fewer units produced due to supply chain disruptions and transportation issues. Chronic physical risks" refers to longer-term changes in climate patterns, such as persistently high temperatures, rising sea levels, altered precipitation patterns, which may result in heat waves or sea level rise (Lavell et al., 2012; Pinchot et al., 2021). Chronic hazards lead to higher capital and operational costs because they might cause infrastructure damage or insufficient water supply for hydropower plants or nuclear and fossil fuel plants to cool down. Changes in water availability, sourcing, and quality, as well as food security and significant temperature fluctuations, may impact the financial performance of firms. These changes can influence all aspects of organizations, including their premises, operations, supply chain, transportation requirements, and employee safety. Burke et al. (2015) observe a non-linear link between global temperature and economic development, for instance, noting that when the global temperature rises over 13 °C, economic growth dramatically decreases. In a similar vein, Kahn et al. (2021) claim that in addition to hindering global economic development, a rise in temperature of 0.04°C per year without mitigation measures might result minimising more than 7% in the real global GDP per capita.

The second category of research on climate risk argues that climate risk has an indirect impact in the form of transition hazards. Transition risks refer to the potential challenges that arise from an organization's ability to effectively and efficiently manage and adapt to both internal and external changes in order to decrease greenhouse gas emissions and shift towards renewable energy sources. The process of transitioning necessitates the implementation of governmental and legislative measures, technological advancements, and market adjustments to effectively satisfy the needs for both mitigating and adapting to climate change. The level of risk and financial consequences resulting from policy changes are contingent upon the characteristics and timing of these policy alterations. As the magnitude of loss and damage resulting from climate change expands, the probability of facing legal action is also expected to rise. Causes for such legal action including the organizations' negligence in reducing the effects of climate change, their inability to adjust to climate change, and their inadequate disclosure of significant financial risks. Furthermore, the adoption of technology advancements or breakthroughs that facilitate the shift towards a more sustainable, energy-efficient economic framework may greatly influence enterprises. Carbon risk is the most prevalent kind of transition risk. Pinchot et al. (2021) analyze the impact of Australia's involvement in the Kyoto Protocol, which requires the nation to cut carbon emissions. They find that enterprises, especially those with high carbon emissions, have more financial difficulties, leading to a reduction in the leverage ratio.

2.1.2 Climate Risks in the Context of Banking

Climate risks may significantly affect financial services, particularly banking services. Physical risk drivers, which may be either immediate or long-term, interact with transition risk drivers to convey climate-related financial dangers via various microeconomic and macroeconomic channels of transmission. These risks differ based on geographical differences, factors that increase or decrease financial and economic conditions, and often manifest as credit, market, liquidity, and operational risks. Climate risk may affect credit risk by directly or indirectly exposing borrowers to a decline in their capacity to repay loans. This can result in increased chances of default and larger losses in the event of default.

Climate-related risks have the potential to initiate risks in the financial market. Financial assets may be affected by a change in investors' perception of profitability if there is a sudden transition with a significant number of assets becoming obsolete. This decline in market value might lead to forced sales at significantly reduced prices, perhaps triggering a severe financial disaster. Banks face market risk in addition to climate risk. Banks that would have negative impacts on their balance sheet due to credit and market concerns may face difficulties in obtaining short-term refinancing, which might possibly create tensions in the interbank lending market. Climate risk may have an influence on the operational risk of banks. If banks face physical hazards that pose a threat to their offices or data centers, they may experience alterations in their operational procedures and an impact on other institutions in their value chain. Fig 1 : The graphic below illustrates the influence of climate hazards on the financial services sector.



Source: Source: Delloitte, 2026

2.1.3 Measures of Climate Risk

Climate risk measures can be categorized into two: The study by Salisu and Oloko (2023) examines two types of measures: those that are influenced by weather conditions and those that are influenced by weather-related losses. Measures based on weather conditions primarily emphasize the physical aspects of climate risk, such as heat waves, intense rainfall, drought, and tropical cyclones (Wiklund, 2023). Temperature and other connected variables are commonly used to measure and assess climate risk. Bressan & Romagnoli (2021) assessed climate risk by using temperature as a metric while investigating the effectiveness of weather and climate derivatives as instruments for managing risk. Furthermore, Shenng et al. (2022) and Shenng, Gupta & Cepnii (2022), measured climate risk by temperature when they were examining the influence of climatic hazards on the economic operations of certain states in the United States.

Weather-related indicators take into account indications of financial damages as well as casualties (such as the number of deaths) caused by extreme weather occurrences.

Extreme weather occurrences typically inflict physical harm to the environment, as well as negative implications for socioeconomic activity. Such losses and interruptions will have a detrimental impact on corporate economic gains (Huang, Kerstein & 2018). Measures of weather-related loss account for both the transition and physical consequences of climate change, as well as other direct impacts on peoples' lives. While physical risk can be defined as material damage to the environment directly caused by natural disasters, for example, droughts, forest fires, hurricanes and floods, the transition effects of climate change are considered to be the aftermath of these environmental transformations in the form of adaptation and sudden policy action (Ren et al., 2022).

The Climate Risk Index, created by Germanwatch and documented in Eckstein et al. (2021), is a significant climate risk assessment that encompasses the tangible and transformative influences of climate change. The index primarily evaluates the extent of harm inflicted by severe climatic occurrences, such as hurricanes, droughts, and heat waves, in various regions and countries. This index tends to be more beneficial for creating climate change strategies at both the national and worldwide, and it looks to be more suited for country-specific analysis. This study employs Global Climate Risk Index as a measure of climate risk.

2.1.4 Bank Performance

In the simplest form, performance of a bank is described as the accomplishment of the bank's goals within the predetermined timeframe, at the lowest possible cost, and with the best use of the available resources (Hajer and Anis, 2018). Performance for a manager may take many different forms, such as profitability, competitiveness for the company or the individual, the work environment, or the standard of services offered to clients. Performance measurement acts as a technique of directing people and inspiring them to perform, just like any other control and management function does. As a result, while measuring performance is the first step in improving performance, improvement cannot occur without a mechanism to obtain feedback on performance. There are two distinct types of performance measurement: financial and non-financial. While non-financial performance measurement is focused on the factors that influence the results, financial performance measurement is focused on the outcomes or results (Dossi and Patelli, 2010). The financial performance of a company is indicative of the efficiency with which it generates profits from the resources it employs in its core business. Additionally, financial performance is employed as a general gauge of an organization's long-term financial health. Investors are informed about a bank's overall health by its financial performance. It paints a picture of the management's effectiveness and the state of the economy. The main financial performance metrics of banks include interest income, net interest margin, earnings per share, return on equity, and return on assets (Alshatti, 2015; Nuhiu, Hoti and Bektashi, 2017; Zhongming, Frimpong and Guoping, 2019). Non-financial performance measures convey performance in terms other than money. Non-financial performance measurements are those that offer performance information in non-monetary terms, such as market share, customer happiness, innovation or new product creation, and staff attrition (Sadek et al., 2012; Marie, Ibrahim and Al Nasser, 2014; Kori, Muathe and Maina, 2020).

2.3 Empirical Review

2.3.1 Climate Risk and Financial Performance

Climate change and climate risk have long been recognized as having a significant influence on a country's economic performance and the financial performance and viability of its firms. (Michalisin & Stinchfield, 2010; Dell et al., 2014; Pan & Qiu, 2022; Ozkan, Temiz, & Yildiz, 2023). A critical review of extant literature shows the following empirical results.

Cevik & Miryugin (2023) made a research contribution by conducting an analysis on the impact of climate change susceptibility on the performance of over 3.3 million nonfinancial enterprises across 24 countries from 1997 to 2019. The dataset utilized to assess climate change susceptibility was obtained from the Notre Dame Global Adaptation Institute (ND-GAIN), with a comprehensive consideration of macroeconomic factors and firm characteristics. Climate change susceptibility has a statistically significant effect on a variety of firm performance indicators, including leverage, interest burden, profitability, and total factor productivity (TFP), according to empirical findings. Access to debt financing for nonfinancial firms operating in countries with greater vulnerability to climate change is typically more difficult to obtain, even at higher interest rates, compared to firms operating in countries with lower vulnerability to climate change. Furthermore, these firms tend to be less productive and profitable. In conclusion, although climate change is unavoidable, policymakers can strengthen structural and financial resilience to withstand disruptions to economic activity, reduce the financial burden on private firms, and generate development opportunities.

Huang, Kerstein, and Wang (2017) conducted an international study to examine the effect of climate risk on financing and performance decisions. The study discovered, through the use of the Germanwatch-compiled and published Global Climate Risk Index, that significant cyclones, heatwaves, and floods increase the volatility of firms' cash flows and earnings. Businesses are more likely to maintain cash reserves in nations with unfavorable weather conditions as a means of bolstering their organizational resilience against weather-related obstacles and generating financial flexibility. Additionally, these businesses have a propensity to distribute fewer cash dividends and to have a greater long-term debt to short-term debt ratio.

Moyo and Wingard (2015) evaluated how climate change affected South African companies' financial performance. The goal of the study was to determine how much financial performance is impacted by climate change response. The study revealed that there is a favorable and statistically significant association between climate-change performance and financial performance.

Sun et al. (2020) conducted a study on the nexus between climate change risks and financial performance of listed mining firms in China. The primary goal of the study was to examine the direct and indirect mechanisms through which climate change risks affect company financial results. The article also used a novel data set, a climate risk indicator with five different categories of climate risks to examine the impact of climate risks on China's mineral listed companies. Based on the findings, a relationship was observed between climate change and financial performance of mining companies. Different resource types provide different risks for mining firms when it comes to climate change. According to this study, the financial performance of mining firms is impacted by climate change risks in both positive and negative ways. To enhance their brand value and provide new competitive advantages for sustained growth, mining businesses have to take proactive measures to execute low-carbon policies and release emission information in response to the concerns posed by climate change.

A study was carried out by Luan et al. (2022) who examined the relationship between climate risk and enterprise performance. Chinese A-listed businesses from 2004 to 2018 were chosen as a sample in this research. The research discovered that the return on assets of businesses is greatly lowered by the total loss caused by meteorological disasters, the most evident of which are downpour, drought, gale, hail, and lightning catastrophes. Furthermore, the typhoon's effects on the provinces will have a significant impact on the return on business assets. most noticeable. The research also suggests that companies with a diversified portfolio would be less susceptible to natural disasters and will assume a lesser portion of the climate risk.

Gurai, Gianfrancesco & Vioto (2023) investigated the connection between US banks' and insurers' financial systemic risk and climate change. The first objective was to determine if, how much, and how soon US banking and insurance sectors' systemic risk responds to billion-dollar weather-related climate catastrophes. The research shows that some severe occurrences might increase the danger to the financial system and offer. Second, using quantile regressions, the research examined the relationship between the systemic risk of the two US financial sectors and the performance of the green and brown market indices. Higher green index levels, with a rising magnitude in tail circumstances, were shown to minimize systemic risk more than a rise in brown indexes. The study's findings support the need for proper policies to be adopted in order to counteract the increase in the frequency and severity of climate catastrophes.

Using data from 56 countries between 1995 and 2012, Lee et al. (2022) investigated how climate risk affected the creation of bank liquidity. In particular, it looks at whether bank and country factors affect the relationship between climate risk and bank liquidity creation. According to the research, Climate adaptation has a positive impact on overall liquidity creation, while climate sensitivity and exposure have a negative effect. According to the study, these effects are especially bad for larger banks with less capital, banks located in emerging and lower-GDP countries, and banks in Asia.

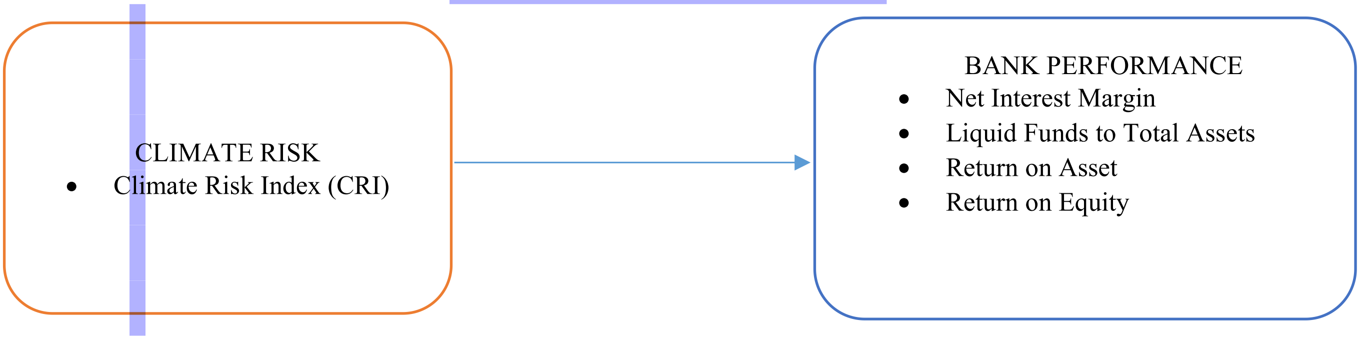
A study was conducted by Dafermo, Nikolaidi & Galanis (2018) to examine the relationship between monetary policy, climate change, and financial stability through the lens of the stock-flow ecological macroeconomic model. Four pivotal findings emerged from their research. Climate change is anticipated to progressively undermine the liquidity of businesses by eradicating their capital and diminishing their profitability. This, in turn, may result in an increased default rate, which has the potential to negatively impact both the financial and non-financial corporate sectors. Secondly, portfolio reallocations prompted by climate change damages may result in a progressive decline in the value of corporate bonds. Furthermore, the expansion of credit could be negatively impacted by climate-induced financial instability, which could further intensify the adverse effects of climate change on economic activity. Furthermore, the adoption of an environmentally friendly quantitative easing (QE) program by corporations has the potential to mitigate climate-induced financial instability and curtail the acceleration of global warming.

Physical channels through which climate risks influence corporate activities and decisions have been empirically demonstrated to disrupt business performance and decisions. As a precaution against climate change, Huang et al. (2018) discovered that climate-related weather events, particularly heat waves, floods, and cyclones, can increase the volatility of a company's earnings and prompt it to retain more capital, reduce dividend payments, and increase long-term obligations. In line with this, Javadi & Masum (2021) establish that drought risk is significantly positively correlated with an increase in the cost of financing for U.S. companies.

Dietz et al. (2016) looked at the physical effects of climate change on the financial system quantitatively. They use the climate value at framework in addition to a typical integrated assessment model. Dietz et al. (2016) assert that a changing environment may result in lower dividend payments from businesses and, therefore, lower prices for financial assets. According to these research, climate risk has the potential to negatively impact the banking industry and have an impact on decisions.

Giang et al. (2021) looked at the relationship between listed industrial companies in Vietnam's financial performance and the risks associated with climate change. Through the use of control variables and an econometric regression model, this research examines the link between climate change risk and corporate performance using both quantitative and qualitative methodologies. The data was taken from 144 listed firms between 2015–2019. This empirical analysis revealed a relationship between industrial businesses' financial performance and climate change. The findings suggest that financial performance is negatively impacted by climate change. There exists a noteworthy and adverse association between humidity risk and the financial performance of corporations. Nonetheless, several independent factors, including rainfall, daylight hours, and temperature, have very little effect on financial performance.

Fig 2 : Conceptual Framework



3.0 Methodology

The study uses quantitative research approach. The sample of this study was limited to ten (10) commercial banks, all been licensed by the Bank of Ghana. These commercial banks include GCB Bank, Ecobank Ghana Limited (EBL), ABSA Bank Ghana Limited, CAL Bank Limited (CAL), Zenith Bank Limited (ZBL), Stanbic Bank Ghana Limited (SBG), Access Bank Ghana Limited (ABG), Republic Bank, Guaranteed Trust Bank (GTB) and Agricultural Development Bank (ADB). The Universal banks were chosen based on the availability of data as well as having greatest market share.

For the purposes of this research, annual panel data spanning the period 2010-2024 were used.

The main explanatory variables that this study employs is climate risk, whilst the dependent variable is bank's financial performance. Climate risk is measured by climate risk index compiled by Global Climate Risk Index and published by Germanwatch.

Bank's financial performance is proxied by net interest margin, return on assets liquid fund to total asset, and return on equity, all derived from PwC Ghana Banking Survey Reports.

3.1 Model Estimation and Specification

This study adapted the model of Lee and Gardner (2017). The following basic empirical research model was developed in the form of Panel data regression equation:

$$BFP_{it} = \beta_0 + \beta_1 CRI_{it} + \beta_2 LV + \beta_3 Bs_{it} + \beta_4 INF_{it} + \beta_5 GDPG_{it} + \mu_{it}$$

Where:

BFP = Bank Financial Performance (proxied by NIM, ROE, ROA and LTA by an index using PCA)

CRI = Climate Risk (proxied by climate risk index)

LV = Bank Leverage (proxied by bank's debt to equity ratio)

Bs = Bank Size (proxied by natural logarithm of bank's total assets)

INF = Inflation (proxied by annual consumer price index)

GDPG = Economic Growth (real GDP growth)

βi, where i = 1, 2, 3, 4 and 5 represents the coefficients of the explanatory variables of the model, and

μ_{it} = the error term.

4.0 Discussion of Results

4.1 Principal Component Analysis

Principal Component Analysis (PCA) is the generic term for a method that leverages advanced underlying mathematical concepts to reduce a number of potentially linked variables into a smaller number of uncorrelated variables known as principal components. (Wu, Massart & De Jong, 1997; Mishra et al., 2017; Salem, 2021). PCA uses a vector space transform to reduce the dimensionality of large data sets (Cao et al., 2003). Principal component analysis was used to create a single financial performance index and institutional quality index consistent with earlier research. This is required because there was no agreement in the literature on a single most acceptable variable for measuring financial success. It is necessary since utilizing the different variables independently may not have sufficiently captured and shown the financial performance status of the chosen listed institutions.

4.1.1 Financial Performance Index (FINP)

The financial performance indicators that were used in the principal component analysis include: net interest margin (NIM), return on assets (ROA), return on equity (ROE) and liquid assets to total assets ratio (LTA). The Eigen Values of the variable variance matrix are calculated in order to perform principal component analysis. According to literature, the classical cutoff value for eigen values is 1 (Lakshmikantham & Sen, 2005; Kouachi, 2006). An eigen value of less than one is less efficient in terms of information than the average single variable. Table 1 displays the eigen values of the correlation matrix of the four (4) different indicators that were used to generate financial performance index (FINP). The total of the eigen values is equal to the number of individual indicators. The first principal component explains the highest variance of 51.69% in all the individual indicators with an eigenvalue of 2.0678. The second principal component explains a variance of 25.84%, with an eigenvalue of 1.0338. The third and fourth principal components were having eigenvalues less than 1, and there cannot be accepted. The first two principal components (PC1 and PC 2) are relevant measures of financial performance as they explain in total of 77.54% of the variance, and also have eigen values greater than the threshold eigen value of 1. The first two principal components were used to generate an index for financial performance in conformance with prior literature.

Table 1: Eigen Values: Financial Performance Indicators

Principal Component	Eigenvalue	Proportion of Variance	Cumulative Proportion
PC 1	2.0678	0.5169	0.5169
PC 2	1.0338	0.2584	0.7754
PC 3	0.6313	0.1578	0.9332
PC 4	0.2671	0.0668	1.0000

Source: Researcher's Own Construction (2026).

4.2 Descriptive Statistics

This section reports on the descriptive statistics of the variables under consideration. The descriptive statistics presented in this section include total number of observations, maximum value, minimum value, mean, and standard deviation of all the variables employed in this study. Table 2 displays the descriptive statistics for each variable. The total number of observations for the study as indicated on the table is 150. As shown in Table2, the maximum and minimum values of the financial performance index (FINP) were 2.67 and -4.48 respectively, with the mean value of 0.92. The mean value of 0.92 represents the average financial performance index for the selected licensed commercial banks for the study. The standard deviations as indicated in Table 2 for financial performance index is 0.73. This implies that the values of financial performance index are minimally dispersed from its mean.

From Table 2, the maximum and minimum values for climate risk index (CRI) are 126.17 and 23.30 respectively, whilst the mean value of climate risk index (CRI) is 66.64. The standard deviation of climate risk index (CRI) is 26.84. As shown in Table 1, institutional quality index (IQ) has a maximum and minimum index of 1.51 and -1.85. The mean value of institutional quality index is standard deviation of institutional quality is 0.0020 indicating that the values of institutional quality index are not distant from the mean. As indicated in Table 1, the control variables; bank size (BZ), leverage (LEV), economic growth (GDPG, and inflation (INFR) have averages of 8.70%, 7.36%, 6.13%, and 12.40% respectively. The standard deviations of the control variables shown in Table.1 indicates that their values of bank size (BZ), leverage (LEV), economic growth (GDPG) and inflation (INFR) are close to their means.

Table 2: Descriptive Statistics of the Variables

Variables	**FINP**	**CRI**	**Bs**	**LEV**	**GDPG**	**INFR**
Mean	0.9168	66.6493	8.7029	7.3623	6.1301	12.4045
Median	0.0768	60.7800	9.1841	5.5422	6.2001	11.1863
Maximum	2.2672	126.1700	10.2051	87.0934	14.0471	19.247
Minimum	-4.4885	23.3000	5.1276	0.0057	0.5139	7.1436
Std. Dev.	0.7323	26.8423	1.2368	2.3792	3.2957	3.6936
Skewness	-0.6673	0.4804	-1.1389	4.9545	0.4981	0.4271
Kurtosis	6.3869	2.5881	3.1495	31.4197	3.1950	1.8907
Observations	150	150	150	150	150	150

Note: These are the definitions of the variables: FINP = Financial Performance Index; CRI = Climate Risk Index; Bs = Bank Size; LEV = Leverage; GDPG = Real GDP Growth; and INFR = Inflation.

Source: Researcher's Own Construction (2026)

4.3 Correlation Analysis

Correlation measures the strength of the linear association between two variables (Gogtay & Thatte, 2017). A positive correlation indicates that both measures are increasing in relation to one another, whereas a negative correlation indicates that as one measure rises, the other falls. Table 3 presents a correlation matrix of the variables under study. As displayed in Table 3, there is negative correlation between climate risk (CRI) and financial performance (FINP). The correlation between climate risk and financial performance is significant at 1%. Institutional quality (IQ) is positively correlated with financial performance (FINP) at 10% significance level. Also, there is positive correlation between the interaction variable (CR_IQ) and financial performance (FINP) at 5% significance level.

Furthermore, bank size (BZ), economic growth (GDPG) and inflation (INFR) are positively correlated with financial performance (FINP) at 10% significance level. On the other hand, leverage (LEV) is negatively and significantly correlated financial performance. The correlation coefficients between the key explanatory variables are all below 70%. It can be concluded that there is no significant degree of multicollinearity between the variables under consideration. Overall, the correlation matrix presented in table in table 4. indicates that there are correlations between climate risk, institutional quality and financial performance of the selected licensed commercial banks. Nevertheless, it should be noted that a correlation between variables does not inherently imply that changes in one variable cause corresponding changes in the other (Stigler, 2005; Altman & Krzywinski, 2015). Hence the researcher employed Generalized Least Square regression to establish the causal relationship between the variables.

Table 3: Correlation Matrix

Variables	FINP	CRI	Bs	LEV	GDPG	INFR
FINP	1					
CRI	-0.2772***	1				

Bs	0.0655*	0.0159	1			
LEV	-0.0228	-0.0921	-0.0357	1		
GDPG	0.0704*	0.0294*	-0.06019	-0.0837	1	
INFR	0.0009*	0.1144*	-0.0047	-4.62E-05***	-0.3289	1

Note: (*), (**) and (***) shows 10.00%, 5.00% and 1.00% level of significance respectively. These are the definitions of the variables: FINP = Financial Performance Index; CRI = Climate Risk Index; Bs = Bank Size; LEV = Leverage; GDPG = Real GDP Growth; and INFR = Inflation.

4.5.1 Panel Unit Root Tests

Table.5 shows the Panel Unit Root Test for the variables utilized in this study. Specifically, the study employed Levin, Lin and Chu (2002) Panel Unit Root test. For Levin, Lin and Chu unit root test, if prob. value is greater than 0.05 (5%), accept the null hypothesis, indicating existence of unit root (non-stationary). Also, if prob. value is less than 0.05 (5%), reject the null hypothesis, implying that non-existence of unit root (stationary). From Table 4, all the variables were constant at levels with the exception of bank size (BZ) and inflation (INFR). After first differencing, bank size (BZ) and inflation (INFR) became stationary at 5% significance level.

Table 4: Panel Unit Root Test – Levin, Lin and Chu Test (2002)

Variables	At Levels		First Difference	
	With Constant and Trend		With Constant and Trend	
	t. statistics	Prob	t. statistics	Prob

FINP	-6.892	0.0000**		
CRI	-11.933	0 .0000**		
Bs	2.791	0.9979	-7.188	0.0000**
LEV	-2.367	0.0090**		
GDPG	-7.542	0.0000**		
INFR	0.053	0.5212	-3.335	0.0000**

Note: (**) indicate the probabilities of 5% level of significance respectively. Probabilities are computed assuming asymptotic normality.

4.6 The Nexus between Climate Risk and Financial Bank Performance

The study utilized Feasible Generalized Least Square (FGLS) regression to control the effects of autocorrelation and heteroskedasticity present in panel fixed effects. Table 5 presents the regression results on the relationship between climate risk, institutional quality, and bank financial performance. The Wald Chi Square Statistic was 18.79 with a p. value less than 5%. This confirms that the independent variables are collectively 'significant' for model. It also confirms that each independent variable present in a model is significant.

The first hypothesis tested on the negative relationship between climate risk and bank financial performance. Based on the results in Table 5, the coefficient of climate risk (CRI) is negative and statistically significant at 5%. The result support the first hypothesis of the study. This implies that climate risk significantly reduces the bank financial performance of the selected commercial banks. Climate risk could have an effect on the bank's buildings and activities, as well as on its users and the business as a whole. Extreme weather events and long-term changes in the climate can cause retail stores and facilities to close, which can hurt customers' reputation and hurt banks' profits and cash flow. The results in this study resonate with the findings of Huang, Kerstein & Wang (2018). Huang, Kerstein & Wang (2018) examined the impacts of climate change on bank performance, and also investigated the mediating role of natural disasters. By using an unbalanced panel of 127 countries between the period 2005-2018, the researchers found a negative association climate change variables to bank performance variables. The study also found a significant mediating effect of climate change on bank performance via natural disasters in high-income countries, but not in low-income countries. The results of this study also confirm the views of Giang et al. (2021) who investigated the impact of climate change risk on financial performance of listed manufacturing firms in Vietnam. Their results found a negative correlation between climate change risk and financial performance. Specifically, humidity risk adversely affects the financial performance of the listed manufacturing.

Table 5: GLS Estimation Results:

Variables	**GLS Estimates**
	Coefficients
CRI	-0.099066**
	(0.002944)
BZ	-0.053438*
	(0.062632)
LEV	0.000108**
	(3.47E-06)
GDPG	-0.056919***
	(4.90E-11)
INFR	-0.023085**
	(0.022437)
_CONS	130.083***
	(33.45665)
N	*150*
Wald chi^2	*18.79*
Prob > chi^2	*0.0045*

Note: Standard errors in parentheses. (*), (**), and (***) indicates that the coefficients are significant at p. values of 10%, 5%, and 1% respectively

5.1 Summary of Findings

Panel regression models were specified to test the link between climate risk and bank financial performance. Specifically, the model was tested using First Generalized

Least Square Regression (FGLS). By and large, the empirical results documented that climate risk is negatively related to bank financial performance for the period under study.

5.1.1 Climate Risk and Bank Financial Performance

Based on the empirical findings in the preceding chapter, climate risk has a significant negative impact on financial performance of the selected licensed commercial banks in Ghana. This implies that climate risk significantly reduces the bank financial performance of the selected commercial banks. Climate risk may have an influence on the bank's premises and operations, as well as its clients and the overall economy. Extreme weather events and long-term changes in the climate may lead to the closure of retail branches or facilities, substantially damaging customers' creditworthiness and badly affecting the profitability and liquidity of banks. The results in this study resonate with the findings of Huang, Kerstein & Wang (2018).

5.2 Conclusion

Studies on the relationship between climate risks and bank financial performance have been under researched. This study sought to examine the nexus between climate risksand financial performance of selected licensed commercial banks in Ghana.
The study specifically used the Generalized Least Square Regression method to control the effects of autocorrelation and heteroskedasticity present in panel data. The results showed that climate risk has a significant negative impact on financial performance of selected licensed commercial banks in Ghana.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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