

Effects Of Climate Change Risks on the Financial Performance of Agricultural Firms in Zambia: Evidence from Kabwe District

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Abstract

Climate change has emerged as one of the most significant and far-reaching challenges confronting agricultural production and economic stability in the contemporary world. Across developing nations, agriculture functions not merely as an economic sector but as the principal foundation of livelihoods, food security, and national development. In Zambia, the agricultural sector employs over sixty percent of the population and contributes approximately nineteen to twenty percent of national gross domestic product, making it central to both economic activity and household livelihoods. This study aims to generate evidence-based insights into how climate change risks on the financial performance of agricultural firms in Zambia. The specific objectives of the study were to identify what specific climate-related factors influence the financial performance of agricultural firms in Kabwe District, to analyse how climate change risks affect the operational costs of agricultural firms in Kabwe District, to determine the extent to which climate change risks impact the profitability of agricultural firms in Kabwe District. The researcher employed a convergent parallel design, a mixed methods approach that collects and analyses quantitative and qualitative data simultaneously. For the quantitative strand, stratified random sampling will be used to select a sample of 239 agricultural firms from a diverse population of 594 in Kabwe District, ensuring that various categories of firms will be adequately represented, thereby increasing the accuracy and generalizability of the results. From the findings, the study concludes that drought is overwhelmingly the most prevalent and most frequently identified climate factor as the primary driver of financial performance disruption, followed by extreme temperatures at 14.6%, floods at 7.1%, and pests and diseases at 5.0%. Revenue stability data corroborated these perceptions, with 46.4% of firms reporting climate-induced revenue reductions of between 26% and 50%, and a further 36.4% reporting reductions exceeding 50%, meaning that 82.8% of sampled firms experience significant climate-induced revenue instability. The mean revenue disruption score of 3.43 (SD = 0.890) reflects a moderately high and broadly consistent level of disruption across the sector. At the regression level, the model for this objective was statistically significant overall ($F = 5.124$, $p = 0.001$), confirming that climate change risks collectively constitute a significant determinant of financial performance and supporting the rejection of H_{02} in favour of H_{12} . Extreme temperature emerged as the sole statistically significant individual predictor of overall financial performance ($\beta = 0.268$, $p = 0.000$), a finding consistent with the qualitative evidence where key informants described how high temperatures reduced labour productivity during peak farming activities and damaged crops during critical growth stages, directly eroding revenue while leaving cost structures elevated. Drought frequency ($\beta = 0.143$, $p = 0.112$), rainfall variability ($\beta = 0.031$, $p = 0.654$), flood occurrence ($\beta = 0.098$, $p = 0.203$), and pest and disease outbreaks ($\beta = 0.076$, $p = 0.317$) were positive but not individually significant, suggesting their primary financial influence is indirect, transmitted through operational cost escalation and output reduction rather than as independently measurable revenue impacts in isolation.

Keywords: Climate change, operational costs, financial performance, agricultural firms and Kabwe District

1. Introduction

Climate change has emerged as one of the most significant and far-reaching challenges confronting agricultural production and economic stability in the contemporary world. Across developing nations, agriculture functions not merely as an economic sector but as the principal foundation of livelihoods, food security, and national development. Zambia is no exception to this reality, as the agricultural sector continues to employ a substantial proportion of the population while contributing meaningfully to gross domestic product. Yet this very sector finds itself increasingly vulnerable to a range of climate-related stressors, among them rising ambient temperatures, erratic and unpredictable rainfall distribution, prolonged dry spells, and the growing frequency of extreme weather events. Such disruptions carry direct consequences for farming operations, diminishing productivity, escalating input costs, and ultimately undermining the financial performance of agricultural enterprises.

In Kabwe District, these pressures manifest with acuteness. Agricultural firms operating within this environment must navigate conditions of heightened climate variability that introduce substantial uncertainty into production planning, resource allocation, and financial forecasting. The compounding nature of these risks, spanning both meteorological and operational dimensions, makes it imperative to understand their effects on firm-level financial outcomes. Generating this understanding is not only academically valuable but carries practical significance for decision-makers, investors, and policymakers engaged in building more resilient agricultural systems. Against this backdrop, the present study examines how climate change risks affect the financial performance of agricultural firms in Kabwe District, with the aim of producing evidence that can meaningfully inform strategies for sustainable agricultural growth.

This dissertation is structured across several interconnected sections. Following the introduction, the study presents the background of the study, the statement of the problem, the purpose of the study, and the specific objectives and research questions. These are succeeded by an examination of the study's significance, its scope, and its limitations and delimitations. The work then develops the theoretical and conceptual frameworks that underpin the inquiry, provides operational definitions of key terms, and closes each chapter with a summary.

Climate change represents one of the most consequential challenges of the twenty-first century, with its effects extending beyond environmental boundaries to penetrate economic systems, agricultural production, and the financial stability of enterprises across the globe. The Intergovernmental Panel on Climate Change has documented that global average temperatures have risen by approximately 1.1 degrees Celsius above pre-industrial levels, with projections indicating that warming is likely to exceed 1.5 degrees Celsius within the next two decades if urgent action is not taken (IPCC, 2023). These changes are accompanied by increasingly erratic precipitation patterns, more frequent drought events, intensified flooding, and prolonged extreme weather episodes, all of which carry profound implications for productive systems that depend on stable climatic conditions. Agriculture, being uniquely tied to climate and environmental inputs, stands among the sectors most severely affected by these transformations.

Globally, the agricultural sector provides livelihoods for an estimated 2.5 billion people and contributes significantly to the gross domestic product of developing economies, yet it remains among the most climate-sensitive industries in existence (FAO, 2021). Research conducted across multiple continents has consistently demonstrated that climate-related risks directly undermine agricultural productivity, elevate operational costs, and introduce severe volatility into the revenue streams of farming enterprises. Raza et al. (2019) established through a comprehensive meta-analysis that rising temperatures and altered precipitation regimes have already reduced global yields of major staple crops, with wheat, maize, and rice recording measurable productivity losses in regions experiencing accelerated warming. Webber et al. (2020) further demonstrated that climate variability forces firms to incur additional costs in irrigation, pest and disease management, and infrastructure maintenance, all of which compress profit margins and threaten the long-term financial viability of agricultural enterprises. At the international policy level, the Paris Agreement of 2015 created binding obligations on signatory states to integrate climate risk into national development planning, including within the agricultural sector (UNFCCC, 2015).

Sun et al. (2023), observes that within Africa, the consequences of climate change for agriculture are particularly acute, given the continent's heavy dependence on rain-fed farming systems, limited access to adaptive technologies, and constrained institutional capacity. Africa accounts for a disproportionate share of global climate vulnerability despite contributing the least to greenhouse gas emissions, and its agricultural sector bears much of this burden (World Bank, 2019). Mwaanga and Nkomoki (2021) noted that climate variability in southern Africa threatens not only food security but also the financial performance and sustainability of agricultural enterprises, as fluctuating rainfall and temperature extremes disrupt planting calendars, reduce harvests, and generate unanticipated operational expenditures. The African Union's Comprehensive Africa Agriculture Development Programme has acknowledged climate change as a structural threat to agricultural productivity and called on member states to mainstream climate risk management into their agricultural policies and investment plans (African Union, 2016), though implementation at the firm level across the continent remains inconsistent. In Zambia, the agricultural sector supports over 70 percent of rural population and contributes approximately nineteen to twenty percent of national gross domestic product, making it central to both economic activity and household livelihoods (World Bank, 2023). The sector operates under conditions of substantial climate vulnerability, characterised by high dependence on rain-fed cultivation, limited irrigation infrastructure, and growing exposure to extreme weather events. Ngoma et al. (2021) projected that rainfall variability and temperature increases could reduce maize yields by as much as thirty percent by 2050 in the absence of robust adaptation measures, while Mumba (2025) confirmed that climate change had already disrupted planting schedules and reduced water availability at the farm level. In Kabwe District specifically, agricultural firms confront these national pressures alongside localised challenges including soil degradation, limited access to credit, and weak infrastructure, all of which compound their financial fragility when climate-related shocks occur. Mumba (2025) further submits that district's agricultural economy, dominated by small- and medium-scale enterprises, is particularly exposed, as these firms typically lack the financial buffers and adaptive capacity necessary to absorb climate-induced losses without significant deterioration in profitability and operational sustainability. It is within this context that the present study situates itself, seeking to generate firm-level empirical evidence on the financial effects of climate change risks in Kabwe District and thereby contribute meaningfully to both the scholarly literature and the practical policy environment for building climate-resilient agriculture in Zambia.

1.2 The Statement of the Problem

Agriculture is one of the most climate sensitive sectors in Zambia, contributing about 19 percent to national GDP and supporting more than 70 percent of rural households (Zambia Statistics Agency, 2023). In Kabwe District, agricultural firms increasingly operate under conditions marked by droughts, extreme temperatures, floods, and erratic rainfall patterns. National climate assessments indicate that Zambia has experienced a temperature rise of 1.3 degrees Celsius over the past four decades and a decline in average rainfall of about 15 percent, trends that have intensified production losses, increased operational disruptions, and weakened financial stability across the agricultural sector (Ministry of Green Economy and Environment, 2022). What is already known from existing literature is that climate related hazards increase production costs, reduce yields, and create revenue instability for agricultural enterprises in many parts of the country (Mulenga and Wineman, 2021). However, these studies focus largely on smallholder farmers or national level trends, leaving limited empirical evidence on how specific climate related factors influence the financial performance of agricultural firms in Kabwe District.

What remains unknown is the precise way in which the major climate risks experienced in Kabwe translate into rising operational costs, declining profitability, and broader financial vulnerability among firms. There is also insufficient understanding of which climate related factors exert the greatest financial pressure on firms and how these pressures differ across firm sizes and operational models. This knowledge gap limits the ability of managers, investors, and policymakers to design targeted adaptation strategies, allocate resources effectively, and strengthen the financial resilience of agricultural enterprises in the district.

Given the increasing frequency and severity of climate hazards in Zambia and the strategic importance of agricultural firms to local economic development, there is a clear need for a study that identifies the specific climate related factors that shape financial performance, explains how climate risks influence operational costs, and determines the extent to which these risks erode profitability. This paper responds to that need by generating empirical evidence that can guide climate responsive planning, inform policy interventions, and support the development of adaptive business practices suited to the climate vulnerable conditions of Kabwe District.

2. Literature Review

2.1 Previous Studies

A study by Lobell et al., (2016) titled “Climate Change Impacts on Crop Production and Farm Costs” conducted in the United States examined how temperature increases and rainfall variability influence operational expenditures among commercial farms. Using longitudinal climate–yield datasets and farm level cost records spanning 35 years, the researchers applied regression modelling to estimate the financial burden of climate variability. Their findings revealed that rising temperatures increased irrigation costs by 18 percent, pesticide use by 12 percent, and labour costs by 9 percent. Extreme heat events were particularly costly, as they required additional investments to maintain crop quality. While the study provides robust evidence of cost escalation, it focuses on technologically advanced commercial farms, which differ significantly from the resource constrained agricultural firms in Kabwe District. The study therefore leaves a gap regarding the experiences of firms operating in developing economies with limited adaptation capacity.

In Australia, Hughes and Gooday (2017) conducted a study titled “Climate Risk and Farm Business Costs” to assess how drought and climate variability affect operational costs. Employing a mixed methods approach that combined climate modelling, surveys, and financial performance analysis across 150 agricultural firms, the study found that drought frequency increased expenditure on supplementary feed, water pumping, and crop protection. Farmers reported a 22 percent rise in operational costs during severe drought years. Although the study offers valuable insights into drought related cost pressures, the Australian agricultural sector benefits from advanced irrigation technologies and government supported adaptation programmes, making the context different from Zambia’s agricultural environment. This creates a gap in understanding how firms in low technology settings cope with similar climate risks.

In India, Kumar and Sharma (2018) conducted a study titled “Economic Effects of Climate Variability on Farm Costs”. Using panel data from 500 farms over a ten-year period, the researchers examined the effects of rainfall variability and heat stress on operational expenditures. Their findings indicated that unpredictable rainfall increased input costs by 15 percent, particularly for fertilizers and pest control, while heat stress raised labour costs due to reduced worker productivity. This study is relevant because India shares structural similarities with Zambia in terms of smallholder dominated agriculture. However, it does not isolate the specific climate risks most responsible for cost increases, leaving a methodological gap that the present study seeks to address.

A study by Zhang et al., (2019) titled “Climate Change and Agricultural Production Costs” conducted in China used econometric modelling to analyse the relationship between climate projections and farm level cost data. The study found that flooding increased machinery repair costs and reduced soil fertility, leading to higher fertilizer expenditure. While the study demonstrates how climate shocks affect cost structures, China’s highly mechanized agricultural system differs from the mixed farming systems common in Kabwe District. This limits the applicability of the findings to Zambia’s context.

In Brazil, Silva and Pereira (2020) conducted a study titled “Operational Cost Implications of Climate Risks in

Agribusiness”. Using a case study approach involving 20 agribusiness firms, the researchers analysed financial documents and conducted interviews to assess the cost implications of climate uncertainty. Their findings showed increased costs in irrigation, pest management, and insurance premiums. Although the study provides insights from an emerging economy, it does not examine small scale agricultural firms typical of Kabwe District. This leaves a gap in understanding how climate risks affect operational costs in smaller, less capital-intensive firms.

Collectively, studies outside Africa consistently show that climate change increases operational costs through irrigation, pest control, labour, and adaptation investments. However, most of these studies focus on large scale or technologically advanced agricultural systems, leaving a gap in understanding how climate risks affect operational costs in resource constrained agricultural firms in Zambia.

In South Africa, Mthembu and Zwane (2017) conducted a study titled “Climate Variability and Farm Operating Costs” to examine how drought and heat waves influence operational expenditures. Using a survey of 200 farmers combined with climate trend analysis, the study found that drought increased water procurement costs, while heat waves raised livestock feed expenses. Although the study provides relevant insights for Southern Africa, it does not examine firm level financial performance, leaving a gap that the present study addresses.

In Kenya, Ochieng (2018) conducted a study titled “Economic Burden of Climate Change on Smallholder Farms”. Using household surveys and cost benefit analysis, the study found that farmers spent more on irrigation, drought resistant seeds, and pest control due to climate variability. While Kenya’s smallholder context is like Kabwe District, the study focuses on households rather than agricultural firms, creating a gap in firm level analysis.

In Ethiopia, Tesfaye and Wolde (2019) conducted a study titled “Climate Risks and Agricultural Production Costs”. Using econometric analysis of farm level cost data, the study found that erratic rainfall increased fertilizer and labour costs, while drought raised irrigation expenses. Although the study demonstrates how climate shocks strain operational budgets, it does not address the financial performance dimension, which is central to the present study.

In Nigeria, Adewuyi (2020) conducted a study titled “Climate Change and Cost Structures in Agribusiness”. Using a cross-sectional survey of 120 agribusiness firms, the study found that climate risks increased costs of inputs, transportation, and storage due to spoilage. While Nigeria’s agribusiness environment shares similarities with Zambia, the study does not isolate climate risks specific to Southern Africa, leaving a geographical gap.

In Ghana, Boateng and Anning (2021) conducted a study titled “Operational Costs and Climate Variability in Agriculture”. Using a mixed methods approach involving interviews and financial analysis, the study found that increased rainfall variability raised costs of soil management and pest control. Although the study reinforces the link between climate variability and rising operational costs, it does not examine firm level profitability, which is a key focus of the present research.

Overall, African studies consistently show that climate risks increase operational costs through irrigation, pest management, soil conservation, and labour. However, few studies examine agricultural firms specifically, focusing instead on households or smallholders. This creates a gap for firm level analysis in Zambia.

In Zambia, Mulenga (2017) conducted a study titled “Climate Variability and Agricultural Costs” focusing on 150 farmers in Central Province. Using survey data, the study found that drought increased irrigation and labour costs, while excessive rainfall raised fertilizer and pesticide expenses. Although the study is geographically relevant to Kabwe District, it focuses on smallholder farmers rather than agricultural firms, leaving a gap in firm level analysis.

Chisanga and Zulu (2018) conducted a study titled “Economic Impacts of Climate Change on Zambian Agriculture”. Using secondary data analysis and climate modelling, the study found that climate variability increased production costs by reducing soil fertility and increasing pest outbreaks. While the study provides national level insights, it does not examine operational costs at the firm level.

In Banda (2019), the study titled “Climate Change and Agribusiness Costs in Zambia” used a case study approach involving 10 agribusiness firms. The findings showed increased costs in irrigation, storage, and pest control due to climate variability. Although this study is closest to the present research focus, it does not examine Kabwe District specifically.

Mwale (2020) conducted a study titled “Climate Risks and Agricultural Input Costs” using quantitative analysis of input price trends and climate data. The study found that input prices rose significantly during drought years, especially for seeds, fertilizer, and chemicals. While the study shows how climate shocks affect cost structures, it does not link cost increases to financial performance.

Finally, Phiri and Tembo (2021) conducted a study titled “Climate Change and Farm Operating Costs” involving 80 commercial farms. Using survey data, the study found that increased heat and rainfall variability raised costs of irrigation, livestock feed, and disease control. Although the study provides evidence from commercial farms, it does not focus on Kabwe District or agricultural firms specifically.

Collectively, Zambian studies confirm that climate change increases operational costs through irrigation, pest control, livestock feed, and input procurement. However, no study focuses specifically on agricultural firms in Kabwe District, creating a clear research gap that the present study addresses.

2.2 Climate Change Risks and Agricultural Firms

Climate change poses an unprecedented threat to global agricultural systems, with notable impacts on temperature regimes, precipitation patterns, and the occurrence of extreme weather events (IPCC, 2022). These environmental shifts threaten to destabilize traditional farming practices, especially in regions heavily reliant on predictable climate conditions.

As temperature fluctuations become more frequent, crop phenology, growth cycles, and yields face significant risks, undermining the resilience of agricultural productivity worldwide (Gaur & Verma, 2023). The economic stability of farming communities is increasingly compromised as climate variability disrupts established farming calendars. Consequently, understanding these climatic stresses from both environmental and financial perspectives becomes vital for sustainable agricultural development (Alam et al., 2025).

Agriculture's dependence on stable climatic conditions means even minor deviations in rainfall and temperature can lead to substantial yield reductions. Empirical studies in Asia and sub-Saharan Africa demonstrate that increased climate variability correlates with production instability, reduced farm incomes, and heightened food insecurity, particularly among smallholder farmers relying on rain-fed agriculture (Aryal et al., 2022; Abebaw, 2025). In South Asia, for instance, rising temperatures and shifting monsoon patterns have contributed to declining yields in staple crops such as rice and wheat, while in sub-Saharan Africa, erratic rainfall and recurrent droughts have driven multi-year crop failures that progressively erode household incomes (Abbebaw, 2025). This instability underscores the importance of climate-smart farming practices and adaptive strategies to buffer against unpredictable weather patterns. Beyond biological productivity, the economic ramifications extend to the financial viability of agricultural enterprises, constraining their capacity to invest in sustainable innovations and long-term productivity improvements (Serrano et al., 2025).

Rainfall variability remains one of the most critical climate-related risks confronting agriculture globally (IPCC, 2022). Irregular rainfall onset, shortened growing seasons, and unpredictable precipitation intensities threaten planting schedules and germination success rates, particularly in regions where farmers have no supplemental irrigation infrastructure to offset deficits. Studies across sub-Saharan Africa reveal that increased rainfall inconsistency results in yield volatility, compelling farmers to divert resources towards risk mitigation rather than productivity enhancement (Babyenda et al., 2023). In the Midwest United States, increased precipitation variability has similarly been associated with delayed planting seasons and heightened crop failure rates, demonstrating that the financial consequences of erratic rainfall are not confined to developing contexts alone (Abbebaw, 2025). This diversion of resources frequently leads to rising operational costs, encompassing additional expenditure on soil management interventions, water procurement, and repeated planting cycles, all which strain farm finances and diminish profitability (Serrano et al., 2025).

Droughts exemplify another severe manifestation of climate variability, particularly within rain-fed agricultural systems where no supplemental water sources exist to buffer the impact of extended dry spells (IPCC, 2022). Prolonged periods of moisture deficit diminish soil quality, impair pasture regeneration, and frequently cause widespread crop failures that push farming enterprises toward financial instability. Globally, recurrent drought episodes contribute to land degradation, declining livestock productivity, and reduced household incomes, fundamentally undermining the long-term resilience of agricultural enterprises (Etana et al., 2024). In sub-Saharan Africa, the cumulative impacts of drought have been particularly acute, with evidence from Zambia indicating that climate-induced dry spells significantly reduce livestock productivity and market viability at the district level, with cascading consequences for farm revenues (Jerie et al., 2025). These compounding effects exacerbate financial vulnerabilities, constrain access to credit, and hinder the capital accumulation necessary for technological upgrades and productive diversification (Rodziewicz and Dice, 2020).

Flooding and extreme precipitation events further threaten agricultural productivity by damaging infrastructure and increasing post-harvest losses (IPCC, 2022). Floodwater can destroy crops, erode fertile soil, and disrupt transportation networks, limiting access to markets and forcing farmers into financial distress (Tembo et al., 2020). Regions such as the United States and China have experienced increased financial volatility in flood-prone areas, with rising recovery costs and asset destruction amplifying economic shocks (Lobell et al., 2016; Zhang et al., 2019). These events highlight the dual exposure of agricultural firms to both drought and flood risks, complicating adaptation strategies and financial planning (Pastor-Sanz et al., 2025).

Extreme temperatures are increasingly recognized as a major determinant of agricultural productivity and economic performance (Okamura et al., 2024). Elevated temperatures impair photosynthesis, accelerate evapotranspiration, and increase pest prevalence, all of which reduce crop yields (IPCC, 2022). Heat stress also compromises livestock systems by lowering feed intake, reproductive efficiency, and milk production, directly impacting profitability (FAO, 2020). Evidence from the United States and China indicates that temperature increases above optimal thresholds have led to significant declines in yields, thereby affecting revenue stability and the financial health of agricultural companies (Lobell et al., 2016; Zhang et al., 2019).

The financial performance of agricultural enterprises is highly sensitive to climate-induced shocks, which can lead to increased costs and reduced revenues (Vasile & Camelia, 2017). Climate risks influence investment decisions, credit access, and insurance premiums, further amplifying the economic vulnerabilities faced by farmers and agribusinesses (Alam et al., 2020). Firms that fail to incorporate climate risk assessments into their strategic planning often experience declines in profitability, shareholder value, and market competitiveness (Cristea et al., 2024). Consequently, climate change impacts necessitate integrated approaches that combine environmental resilience with financial risk management. In addition to physical risks, climate change introduces financial uncertainties that influence market behaviour and investor confidence in agricultural sectors (Khalfaoui et al., 2024). Fluctuations in crop yields, livestock productivity, and input costs increase market volatility, making it more challenging for farmers and firms to plan long-term investments (Sun et al., 2023). Research indicates that financial institutions are increasingly incorporating climate risk disclosures into their decision-making processes to better assess exposure and ensure sustainability (Megeid, 2024). This evolving landscape underscores the importance of innovative financial instruments and climate-resilient investment strategies for the future.

of agriculture.

Furthermore, climate change disproportionately affects smallholder farmers, who often lack access to risk mitigation tools such as insurance, credit, and climate information (Malambo, 2019). These farmers are more vulnerable to yield shocks and income fluctuations, which can plunge them into poverty and food insecurity (Maluti & Kabwe, 2025). The adoption of climate-smart agricultural practices, such as conservation farming and crop diversification, has shown promise in enhancing resilience and stabilizing incomes (Kalinda et al., 2017). However, scaling these practices requires supportive policies, access to finance, and capacity-building initiatives tailored to smallholder contexts (Hamazakaza et al., 2022).

The multifaceted impacts of climate change on agriculture necessitate comprehensive approaches that integrate environmental management with financial resilience. Adaptation strategies, including technological innovations, policy interventions, and improved risk-sharing mechanisms, are essential to mitigate the adverse effects of climate variability (Kazancoglu et al., 2024). Strengthening the climate resilience of agricultural systems will require collaboration among governments, financial institutions, and farming communities, ensuring that both biological and economic productivity are safeguarded against future climatic shocks (Vuković et al., 2022). Only through such holistic efforts can sustainable agricultural development be achieved in the face of an uncertain climate future (Alam et al., 2025).

In Sub-Saharan Africa, the impacts of climate change are especially severe due to the region's heavy reliance on rain-fed agriculture and the limited development of irrigation infrastructure (Kalinda et al., 2017). Most farmers depend on unpredictable rainfall for planting and harvesting cycles, making their livelihoods highly vulnerable to climatic fluctuations. This dependence amplifies the effects of irregular precipitation, which often results in poor crop establishment and reduced yields (Mthembu & Zwane, 2017). The region's fragile agricultural systems lack adequate buffer mechanisms, leaving smallholder farmers exposed to climate shocks with little capacity for adaptation. Consequently, climate variability threatens to undermine food security and rural livelihoods across many African countries.

Rainfall variability is a critical concern across Sub-Saharan Africa, with studies in South Africa and Kenya demonstrating its adverse effects on agricultural productivity (Ochieng, 2018). Inconsistent rainfall leads to yield volatility, compelling farmers to divert resources toward risk mitigation measures rather than productivity enhancement. For example, farmers often increase investments in soil conservation, water harvesting, and drought-resistant crops, which heighten operational costs (Deressa et al., 2009). Such practices, while necessary, strain limited household resources and often fail to fully offset the damage caused by erratic weather patterns. As a result, many smallholder farmers experience recurrent income shocks and increased vulnerability to poverty.

Droughts are among the most devastating manifestations of climate change in Africa, causing widespread land degradation and diminishing livestock productivity (Wahab et al., 2022). Prolonged dry spells reduce soil moisture, impair pasture regeneration, and lead to significant crop failures, especially in arid and semi-arid regions (Tefaye & Wolde, 2019). These recurrent drought events weaken the resilience of agricultural households and enterprises, pushing them further into poverty. The loss of forage and water sources also diminishes household income, reduces food availability, and increases food insecurity across vulnerable communities (Adewuyi, 2020). The cumulative effects threaten both short-term livelihoods and long-term agricultural sustainability.

Research across the continent highlights that recurrent drought exacerbate financial vulnerabilities in African agricultural enterprises (Tefaye & Wolde, 2019; Adewuyi, 2020). Limited access to credit, insurance, and other risk management tools prevent farmers from recovering quickly from drought-induced losses (Alam et al., 2020). Many farmers are unable to invest in climate adaptation strategies due to financial constraints, which perpetuate a cycle of vulnerability. Moreover, land degradation resulting from drought weakens soil fertility, further reducing crop yields and increasing dependency on external aid or food imports (Boateng & Anning, 2021). These factors collectively undermine the economic stability of farming communities.

Flooding and extreme precipitation events also pose significant risks to African agriculture, especially through destruction of infrastructure and post-harvest losses (IPCC, 2022). Heavy rains often lead to the erosion of fertile soil, damage to roads, storage facilities, and irrigation systems, and increased incidences of disease outbreaks (Alam et al., 2020). Regions such as West Africa and East Africa frequently experience flash floods that wipe out entire crops and livestock, undermining household incomes and national food security (Boateng & Anning, 2021). The high costs associated with recovery and rebuilding further strain limited national budgets and individual farm finances.

Studies indicate that flood-prone areas in Africa face heightened financial volatility due to asset destruction and the high costs of recovery (Lobell et al., 2016). The unpredictability of flood events complicates planning and investment for farmers, discouraging long-term commitments to productivity-enhancing practices. Post-flood recovery often requires significant financial resources, which many smallholder farmers and agricultural firms lack. This leads to a cycle of repeated losses, reduced investment in resilience measures, and increased poverty levels (Zhang et al., 2019). As climate-induced floods become more frequent, their economic toll on African agriculture deepens.

Extreme temperatures are also recognized as a major factor affecting agricultural productivity and economic stability in Africa (Siatwiinda et al., 2021). Elevated temperatures above crops and livestock thresholds impair growth processes, accelerate evapotranspiration, and increase pest and disease prevalence. For example, heat stress reduces crop yields in countries like Zambia, which rely heavily on maize and other staple crops (Siatwiinda et al., 2021). Livestock systems are similarly affected, with heat-induced stress lowering reproductive rates, milk production, and feed efficiency. These temperature effects threaten to reduce farm incomes and increase the costs associated with mitigating heat stress impacts. Temperature increases above optimal thresholds also impact the quality and quantity of harvests, reducing overall

productivity (IPCC, 2022). In many African regions, farmers have observed declining yields during heatwave episodes, which coincide with rising temperatures. This decline not only diminishes immediate income but also hampers food availability in local markets, contributing to inflation and food insecurity (Adewuyi, 2020). The economic consequences extend to national food systems, especially in countries where agriculture accounts for a large proportion of GDP and employment.

In addition to physical impacts, climate change influences the financial health of African agricultural firms through increased insurance premiums, higher borrowing costs, and reduced access to credit (Alam et al., 2020). Many smallholder farmers lack formal insurance schemes, making them highly susceptible to climate shocks without safety nets (Khalfaoui et al., 2024). Without adequate risk management tools, farmers are less likely to adopt climate-smart practices or invest in productivity-enhancing technologies. This financial vulnerability hampers efforts to build resilient agricultural systems capable of withstanding future climate stresses.

Furthermore, climate risks often result in market disruptions, affecting prices and trade flows within and across African countries (Vasile & Camelia, 2017). Crop failures due to droughts, floods, or heatwaves lead to supply shortages, driving up prices and creating inflationary pressures. Conversely, surplus production during favorable periods can lead to price collapses, discouraging farmers from investing in productivity improvements (Sun et al., 2023). These market fluctuations increase financial uncertainty for farmers and agribusinesses, reducing their capacity to plan and invest for the future.

Smallholder farmers, who constitute most African agricultural producers, are particularly vulnerable to climate variability due to limited access to financial services and climate information (Malambo, 2019). Many lack access to affordable credit, insurance, or extension services that could help them adapt (Hamazakaza et al., 2022). The absence of effective risk-sharing mechanisms constrains their ability to adopt resilient farming practices such as crop diversification and conservation agriculture. Strengthening financial inclusion and climate information dissemination can significantly improve their adaptive capacity (Kalinda et al., 2017).

The adoption of sustainable agricultural practices, such as conservation farming or agroforestry, has shown promise in increasing resilience and stabilizing incomes in Africa (Khalfaoui et al., 2024). These practices enhance soil fertility, improve water retention, and reduce vulnerability to droughts and floods (Maluti & Kabwe, 2025). However, widespread adoption remains limited by factors such as access to inputs, knowledge gaps, and policy deficiencies. Addressing these barriers through targeted programs and supportive policies is crucial for scaling up climate-resilient farming systems across the continent.

The impacts of climate change on Africa's agriculture are multifaceted, affecting physical productivity, economic stability, and social well-being (Mthembu & Zwane, 2017). Without concerted efforts to improve infrastructure, access to finance, and knowledge dissemination, vulnerable communities will continue to face heightened risks of poverty, food insecurity, and environmental degradation. Building resilience requires integrated strategies that combine technological, financial, and policy interventions tailored to local conditions (Zhang et al., 2019). Strengthening adaptive capacity will be essential to ensuring sustainable agricultural development amid a changing climate (Vasile & Camelia, 2017).

In Zambia, climate change impacts are especially acute due to the country's heavy reliance on rain-fed agriculture, which accounts for a significant portion of its food production and rural livelihoods (Kalinda et al., 2017). The limited development of irrigation infrastructure exacerbates vulnerability, making farmers highly susceptible to fluctuations in rainfall patterns. Variability in precipitation often results in delayed planting, reduced germination, and lower yields, particularly for staple crops like maize (Siatwiinda et al., 2021). The dependence on unpredictable rainfall thus creates a fragile agricultural system that struggles to adapt to changing climatic conditions. This situation elevates risks for both subsistence farmers and commercial agribusinesses.

Research indicates that rainfall variability in Zambia has a direct negative impact on maize productivity, which is a primary food staple and cash crop in the country (Chilambwe et al., 2022). During drought periods, farmers face significant yield reductions, leading to food shortages and income loss. Okamura et al. (2024) also show that rising temperatures further undermine agricultural efficiency by accelerating crop maturity cycles and increasing evapotranspiration. These climatic stresses compound the challenges faced by farmers, especially smallholders, who lack the capacity to implement large-scale adaptation measures. As a result, their economic resilience is seriously compromised.

Studies in Zambia have confirmed that climate change increases operational costs through various channels, including irrigation, pest control, and soil management (Mulenga, 2017). Drought conditions necessitate increased expenditure on supplementary irrigation, which is often inaccessible or unaffordable for smallholders. Excessive rainfall, on the other hand, raises fertilizer and pesticide expenses due to increased pest outbreaks and soil erosion (Chisanga & Zulu, 2018). These rising costs diminish profit margins and threaten the financial sustainability of farming enterprises, especially in vulnerable districts. The economic burden imposed by climate variability hampers efforts to scale sustainable practices and technological innovations.

Despite extensive empirical documentation, significant gaps remain in understanding the long-term economic implications of climate change on Zambia's agricultural sector (Pastor-Sanz et al., 2025). Most studies focus on immediate yield losses without examining how these shocks influence firm survival, debt levels, or investment capacity over time (Mulungu et al., 2024). For instance, little is known about how recurrent climate shocks influence farmers' access to credit or their ability to adopt climate-smart innovations. Addressing these gaps requires interdisciplinary research that combines environmental science, agricultural economics, and business performance analysis to develop a comprehensive understanding of resilience and vulnerability (Auci et al., 2021).

The heterogeneity of farm types, sizes, and ownership structures further complicates the climate risk landscape in Zambia. Smallholder farmers, large commercial farms, and cooperatives experience different levels of exposure and adaptive capacity (Kazungu, 2024). Smallholders often lack access to credit, insurance, and extension services, making them more vulnerable to climate shocks and less able to invest in resilience measures (Hamazakaza et al., 2022). Larger firms, although better equipped, are not immune to the financial stresses caused by climate variability, which can impair their operational efficiency and market competitiveness (Gaur & Verma, 2023). A nuanced understanding of these differences is essential for designing targeted interventions.

Furthermore, climate change affects the entire value chain, from production to marketing and processing, thereby influencing firms' financial performance (Cristea et al., 2024). Disruptions caused by droughts or floods lead to delays in harvesting, increased post-harvest losses, and reduced market supply. These effects elevate transaction costs and reduce revenues, which in turn impact firms' profitability and ability to reinvest (Alam et al., 2025). The financial strain often results in increased borrowing, delayed payments, and, in extreme cases, bankruptcy, particularly among small and medium-sized enterprises (Pastor-Sanz et al., 2025).

Climate-induced shocks also influence farmers' risk preferences and decision-making processes. Research indicates that farmers tend to become more risk-averse after experiencing repeated shocks, which affects their willingness to invest in productivity-enhancing technologies or diversification strategies (Mulungu et al., 2024). For instance, crop diversification, a widely promoted adaptation strategy, often involves a trade-off between income stability and technical efficiency, especially for resource-constrained farmers (Mzyece & Ng'ombe, 2020). Understanding these behavioral responses is crucial for designing effective policies and financial instruments that promote resilience.

In addition, the adoption of climate-smart agricultural practices, such as conservation farming, crop rotation, and water harvesting, has shown promise in reducing vulnerability and improving productivity (Kalinda et al., 2017). However, the adoption rate remains limited due to factors such as lack of access to inputs, knowledge gaps, and inadequate extension services (Hamazakaza et al., 2022). Scaling these practices requires coordinated efforts involving government policies, financial incentives, and capacity-building initiatives tailored to local contexts. Such interventions can help farmers better manage climate risks and improve their economic outcomes over the long term.

Recent studies also highlight that climate change impacts are not uniform across regions and farm types, necessitating differentiated adaptation strategies (Vuković et al., 2022). For example, smallholder farmers in semi-arid areas are more vulnerable compared to larger commercial farms in more favorable zones. Therefore, policy responses must consider local climate conditions, resource endowments, and social factors to be effective (Khalfaoui et al., 2024). Moreover, integrating climate risk disclosures into corporate strategies can enhance transparency and attract investment in climate-resilient agriculture, fostering sustainable growth (Megeid, 2024).

Despite the growing body of research, there remains a dearth of longitudinal studies examining how climate shocks influence firm performance, debt levels, and investment decisions over extended periods (Intan et al., 2024). Such studies are essential for understanding the long-term economic impacts of climate variability and for developing appropriate financial instruments, including climate insurance, value chain financing, and risk-sharing mechanisms (Kazancoglu et al., 2024). These tools can help farmers and firms better withstand future shocks, ensuring the sustainability of agricultural livelihoods in Zambia.

Climate change poses multifaceted challenges to Zambia's agricultural sector, affecting productivity, operational costs, financial stability, and overall economic resilience (Tembo et al., 2020). Addressing these issues requires a comprehensive approach that combines technological innovation, financial instruments, policy reforms, and capacity-building. It is critical to understand the heterogeneity of farm types and regional vulnerabilities to design targeted interventions effectively. Building resilience within Zambia's agricultural system will depend on integrating climate science with economic analysis and fostering stakeholder collaboration across sectors (Auci et al., 2021). Only through such multi-dimensional efforts can the country hope to secure sustainable agricultural development amid ongoing climate challenges (Wahab et al., 2024).

2.3 Climate Factors Influencing Financial Performance

Financial performance in agriculture is fundamentally connected to environmental stability because the sector's productivity heavily depends on predictable climate conditions (Alam et al., 2020). When climate variability introduces droughts, floods, or temperature extremes, it disrupts crop cycles and livestock health, leading to unpredictable yields. These disruptions directly affect revenue streams, as farmers and agribusinesses depend on stable harvests for income. Moreover, climate shocks influence the costs of production necessitating investments in mitigation and adaptation efforts which can further strain financial resources. As a result, the entire economic viability of agricultural firms becomes vulnerable when environmental conditions become erratic.

Empirical evidence from countries like China and the United States illustrates that increased exposure to droughts and floods results in significant reductions in profit margins (Liu et al., 2020). In these nations, climate-related disasters have led to substantial crop losses, forcing firms to absorb higher costs related to water management, pest control, and infrastructure repairs (Lobell et al., 2016). Such events destabilize cash flows and reduce liquidity, impairing firms' ability to meet short-term obligations or invest in growth initiatives. Over time, persistent financial volatility hampers the capacity of these firms to reinvest profits into technological upgrades or expanded production, undermining their long-term competitiveness.

These climate-induced financial shocks also diminish firms' capacity to access credit, as lenders perceive higher risks

associated with environmental volatility (Wahab et al., 2024). Banks and financial institutions often tighten lending criteria for agriculture-related loans when climate risks are high, which restricts farmers' and firms' ability to finance operational costs or capitalize on new market opportunities. This credit constraint further limits their resilience to future shocks, creating a vicious cycle where climate variability not only reduces immediate profitability but also hampers future growth prospects. The cumulative effect is a sector increasingly vulnerable to environmental disturbances.

In addition to revenue reductions, climate variability can cause substantial increases in operational costs. Farmers and agribusinesses face higher expenses for irrigation, soil conservation, pest control, and infrastructure repairs after extreme weather events (Deressa et al., 2009). For example, droughts elevate the need for supplementary irrigation, which can be costly due to water sourcing and infrastructure investments. Floods damage roads, storage facilities, and machinery, necessitating repairs that divert financial resources from productive activities. These added costs erode profit margins and reduce the overall financial resilience of firms, making it more difficult for them to adapt and recover from future climate shocks.

In countries like the United States and China, the limited reach of irrigation infrastructure exacerbates the financial strain caused by climate extremes (Lobell et al., 2016; Zhang et al., 2019). During drought periods, many firms are compelled to invest in costly water transportation systems or drill boreholes to access groundwater, significantly raising operational expenses. These investments are often capital-intensive and may not be sustainable in the long run, especially for small and medium-sized enterprises with limited financial capacity. The increased costs directly cut into profit margins, reducing the funds available for innovation or diversification, which are crucial for building resilience against climate variability.

The heightened operational costs due to climate stress also influence firms' strategic decisions, often leading to reduced investment in productivity-enhancing technologies (Alam et al., 2020). When costs escalate unexpectedly, firms tend to prioritize short-term survival over long-term growth, delaying capital expenditures or technological upgrades. This conservative approach can hinder innovation and adaptive capacity, making firms more vulnerable over time. Furthermore, as the frequency and severity of climate shocks increase, the cumulative financial burden discourages investment in sustainable practices, perpetuating a cycle of vulnerability and underperformance (Wahab et al., 2024).

Climate change also impacts market dynamics, with fluctuations in supply and demand affecting prices and profitability (IPCC, 2022). Crop failures lead to shortages that push prices upward temporarily, but in surplus years, prices can plummet, discouraging farmers from investing in future productivity (Bryan et al., 2013). These price swings create financial uncertainty, making it difficult for firms to plan effectively or secure stable income streams. Such volatility can deter long-term investment, reduce confidence among financial stakeholders, and ultimately weaken the sector's stability and growth prospects.

The financial impacts of climate variability are not confined to crop losses but extend to the entire supply chain, affecting input suppliers, processors, and exporters (Alam et al., 2020). Disrupted supply chains due to weather events cause delays, increased transportation costs, and spoilage, all of which add financial strain to firms. For example, damage to roads or storage facilities can result in lost inventory and higher logistics expenses. These cascading effects further undermine profitability and can lead to a reduction in export competitiveness, especially in global markets where price and quality standards are critical (Wahab et al., 2024).

In response to these challenges, some countries have adopted innovative financial mechanisms like weather-indexed insurance, mobile banking, and climate risk disclosures to buffer their agricultural sectors against environmental shocks (Alam et al., 2025). These tools aim to provide timely financial relief and promote resilience by enabling farmers and firms to recover quickly after disasters. However, the adoption of such instruments remains limited in many contexts due to issues of awareness, affordability, and accessibility, especially among smallholders (Sheeraz et al., 2024). Enhancing the reach and effectiveness of these financial innovations is crucial for reducing sector-wide vulnerabilities.

At the corporate level, climate risks influence firms' investment decisions, risk management strategies, and stakeholder perceptions (Chen & Wang, 2025). Listed agricultural companies are increasingly required to disclose climate-related risks and adopt sustainability standards to maintain investor confidence (Sandberg et al., 2023). Companies with better risk management practices tend to perform more stably financially, attracting investment even during adverse climate periods (Vuković et al., 2022). Conversely, firms that neglect climate risks may face declining valuations, higher borrowing costs, and reduced access to capital, which can impede their growth and innovation capacity (Cristea et al., 2024).

On a macroeconomic level, climate variability can lead to increased government expenditure on disaster relief, infrastructure repairs, and social safety nets, straining public finances (Pankratz et al., 2023). The economic uncertainty generated by recurrent climate shocks discourages foreign direct investment and can lead to currency depreciation and inflationary pressures. Governments and financial institutions must develop integrated policies, including climate-smart financing, risk-sharing mechanisms, and capacity-building programs, to mitigate these macroeconomic risks (Kazancoglu et al., 2024). Such measures can help stabilize the sector and foster sustainable growth despite environmental uncertainties. Internationally, the impact of climate change on agricultural financial performance has garnered increasing attention from policymakers, investors, and researchers. Countries that proactively implement climate adaptation strategies tend to experience less severe economic disruptions (Sun et al., 2023). Climate-resilient infrastructure, diversified cropping systems, and sustainable land management are critical components of these strategies (Alam et al., 2020). Moreover, integrating climate risk disclosures and ESG criteria into investment decisions can incentivize firms to adopt more sustainable practices, consequently reducing their vulnerability (Cristea et al., 2024). These approaches foster resilience not only at the firm level but also across the broader economy.

The global evidence underscores that climate variability and extreme weather events significantly influence the financial health of agricultural enterprises across regions (Liu et al., 2024). Whether through direct damage to crops and infrastructure or indirect market fluctuations and investment risks, the sector faces heightened vulnerabilities. Building resilience requires comprehensive strategies that encompass technological innovation, financial instruments, policy reforms, and transparent risk communication (Wahab et al., 2024). Such integrated efforts can help safeguard profitability, ensure sector sustainability, and promote economic stability in an era of increasing climate uncertainty (Alam et al., 2020). Climate-related factors are critical determinants of financial performance in agriculture worldwide. Addressing these risks proactively through insurance, sustainable practices, and transparent reporting will be essential to foster resilience. Policymakers, investors, and industry stakeholders must collaborate to develop adaptive solutions that mitigate environmental impacts and stabilize financial outcomes. As climate change accelerates, the importance of integrating environmental risk management into financial planning becomes ever more urgent. Only through such comprehensive approaches can the sector secure long-term profitability and contribute to broader economic resilience amid mounting environmental challenges (Wahab et al., 2024; Sun et al., 2023).

Across Africa, climate variability has been found to significantly impact the financial performance of agricultural firms. Studies in countries like Nigeria and Malaysia demonstrate that increased exposure to droughts and floods reduces profit margins and destabilizes cash flows in agricultural enterprises (Wahab et al., 2024; Alam et al., 2020). These financial shocks undermine reinvestment capacity and reduce competitiveness within domestic and international markets (Liu et al., 2020).

Revenue instability is a major concern, as firms operating in high-risk climatic zones across Sub-Saharan Africa experience greater fluctuations in annual revenue compared to those in more stable regions (Mulungu et al., 2024). Crop failures resulting from rainfall deficits or excessive heat reduce harvest volumes, thereby lowering sales income (Siatwiinda et al., 2021). Such volatility discourages long-term planning and limits capital expansion opportunities (Bryan et al., 2013). Operational costs also rise significantly under climate stress in Africa (Deressa et al., 2009). Farmers incur additional expenditures on irrigation, pest control, soil restoration, and infrastructure repairs following extreme events (Pastor-Sanz et al., 2025). In countries like South Africa and Kenya, limited irrigation coverage forces firms to rely on costly water transportation or borehole investments during drought periods, leading to cost escalations that reduce net profit margins and weaken financial resilience (Mthembu & Zwane, 2017; Ochieng, 2018).

The impact of climate change risks on the profitability of agricultural firms across Africa has been well-documented. Studies in countries like Nigeria and South Africa have found that increased exposure to droughts, floods, and extreme temperatures significantly reduces profit margins and undermines the long-term financial viability of agricultural enterprises (Wahab et al., 2024; Mthembu & Zwane, 2017). Crop failures and yield reductions driven by climate variability are a major contributor to the decline in profitability (Siatwiinda et al., 2021).

Firms operating in high-risk climatic zones experience greater profit volatility and lower returns on investment compared to those in more stable regions (Mulungu et al., 2024). The inability to maintain consistent revenue streams due to unpredictable weather patterns further exacerbates the profitability challenges faced by African agricultural firms (Tembo et al., 2020). Additionally, the rise in operational costs associated with climate change, such as increased expenditures on irrigation, pest control, and infrastructure repairs, significantly erode profit margins in the African agricultural sector (Deressa et al., 2009).

Smallholder farmers and cooperatives often lack the financial resources to effectively manage these cost pressures, leading to a disproportionate decline in their profitability (Kazungu, 2024). This dynamic perpetuates a cycle of vulnerability where climate shocks exacerbate poverty and reduce adaptive capacity (Tembo et al., 2020). Crop diversification has been shown to stabilize income streams, but its effectiveness depends on market integration and price stability (Liu et al., 2020). Furthermore, the literature inadequately evaluates the role of financial instruments such as index-based insurance and microfinance in cushioning profitability shocks (Chanda et al., 2025). Pastor-Sanz et al. (2025) argue that integrated financial-risk frameworks remain underdeveloped in African agricultural contexts, limiting the ability to quantify the cost-effectiveness of adaptation measures and their impact on profitability. Future research should therefore focus on developing comprehensive models that integrate environmental risk modelling with financial cost-benefit analysis to determine optimal adaptation strategies and their impact on the financial performance of agricultural firms in Africa (Auci et al., 2021). Such frameworks would support evidence-based policy interventions and strengthen the financial resilience of the agricultural sector.

The role of institutional frameworks, climate finance readiness, and policy interventions in mediating the relationship between climate risks and financial performance also remains underexplored in the African context (Tembo et al., 2020). Addressing this gap would provide valuable insights into the effectiveness of support systems and their ability to enhance the adaptive capacity and financial sustainability of agricultural enterprises. Cooperative structures have been identified as a potential avenue for strengthening the financial resilience of smallholder farmers, but the specific governance challenges and performance outcomes require further investigation (Mundia et al., 2022). Enhancing the efficiency and financial management practices of agricultural cooperatives could play a crucial role in improving the overall financial performance of the sector.

The literature review has highlighted the significant impact of climate variability on the financial performance of agricultural firms across Africa, with smallholder farmers and resource-constrained enterprises being the most vulnerable. However, the heterogeneous risk exposure and the effectiveness of adaptation strategies remain underexplored,

particularly in the context of specific countries and regions. Addressing these gaps will be crucial for developing targeted policy interventions and support mechanisms that can strengthen the financial resilience of the agricultural sector in Africa. The review of the African literature emphasizes the pervasive nature of climate-related financial risks, the disproportionate impact on smallholder farmers and cooperatives, and the need for integrated frameworks that combine environmental, economic, and business performance analysis. This provides a solid foundation for the subsequent investigation of the Zambian context, where the agricultural sector faces significant climate change challenges and the need for evidence-based policy solutions.

In Zambia, climate variability has emerged as a critical factor affecting the financial stability of agricultural firms. Research indicates that increased frequency and intensity of droughts, floods, and extreme temperatures have tangible impacts on farm profitability (Siatwiinda et al., 2021). These climatic events disrupt planting and harvesting cycles, leading to reduced yields and lower revenue streams. Smallholder farmers and large agribusinesses alike face heightened risks of financial losses, which threaten their operational sustainability. The economic shocks from climate fluctuations also affect access to credit and insurance, further exacerbating vulnerabilities across the sector. Overall, climate variability undermines the confidence of investors and stakeholders in Zambia's agricultural economy.

Empirical studies demonstrate that droughts cause significant reductions in crop yields, leading to diminished profit margins and unstable cash flows (Okamura et al., 2024). During drought periods, farmers often must reduce planting areas or abandon crops altogether, which directly results in lower sales and income. Flooding, on the other hand, damages crops and infrastructure, making recovery costly and time-consuming (Tembo et al., 2020). These disruptions not only impact immediate income but also have long-term consequences by discouraging reinvestment in improved farming practices. Consequently, the sector struggles to maintain consistent growth amid changing climatic conditions.

Revenue instability is a major concern for Zambia's agricultural firms, especially those operating in high-risk climatic zones. Data shows that firms in these zones experience greater fluctuations in annual revenue compared to firms in more stable regions (Mulungu et al., 2024). Rainfall deficits and excessive heat reduce harvest volumes, leading to unpredictable income streams that hinder financial planning. This unpredictability discourages farmers from making long-term investments, such as purchasing new equipment or adopting sustainable practices. As a result, the sector becomes trapped in a cycle of short-term survival strategies rather than sustainable growth and development.

Crop failures caused by erratic weather patterns have severe implications for Zambia's food security and rural livelihoods (Siatwiinda et al., 2021). When harvests are reduced, farmers' income drops sharply, limiting their ability to repay loans or invest in future planting seasons. This volatility can also lead to increased reliance on government support or aid, which may not be sustainable in the long run. Additionally, unstable revenues affect local markets, as fluctuations in supply lead to price volatility that can disadvantage farmers and consumers alike. Such economic instability hampers the sector's ability to contribute meaningfully to national economic growth. The unpredictability of rainfall and temperature extremes discourages long-term planning among farmers and agribusinesses (Hamazakaza et al., 2022). Without reliable climatic forecasts, farmers often adopt conservative strategies, reducing crop diversity or delaying investments in technology. This cautious approach limits productivity improvements and innovation, which are essential for climate resilience. Moreover, the lack of predictable income makes it difficult for firms to access financing, as lenders perceive higher risks in high-variability environments. Consequently, financial institutions are less willing to extend credit, further constraining growth opportunities.

Operational costs in Zambia's agriculture also escalate significantly under climate stress, affecting farm profitability (Deressa et al., 2009). Farmers incur higher expenses on irrigation, pest control, and soil restoration after extreme weather events. For instance, droughts often necessitate additional irrigation, which involves costly water sourcing and infrastructure investments (Kalinda et al., 2017). Floods damage roads, storage facilities, and equipment, requiring costly repairs and replacements. These increased costs reduce net profit margins and stretch limited financial resources, making it harder for firms to recover from shocks and invest in adaptive measures.

The limited irrigation infrastructure in Zambia exacerbates these financial challenges (Hamazakaza et al., 2022). Many farmers and firms are forced to rely on groundwater, which requires drilling boreholes, a capital-intensive process that not all can afford. During drought periods, reliance on water transportation or borehole investments becomes a necessity, leading to substantial cost escalations. These investments are often beyond the reach of smallholder farmers, who form most producers in Zambia, further widening the gap between large-scale and small-scale agriculture. The increased operational costs during droughts thus significantly cut profit margins.

Furthermore, the scarcity of reliable water sources hampers the ability of farmers to implement sustainable water management practices (Siatwiinda et al., 2021). Many farmers are unable to adopt efficient irrigation systems, which could mitigate the effects of droughts, due to high costs and limited technical capacity. This dependency on costly water sourcing methods makes farms more vulnerable to climate shocks and reduces overall resilience. The inability to effectively manage water resources leads to lower productivity, higher costs, and increased financial instability, especially during prolonged dry spells. Climate variability also influences input prices, with higher costs for seeds, fertilizers, and pesticides during adverse weather conditions (Tembo et al., 2020). For example, increased pest incidences following floods or heatwaves necessitate additional pest control measures, further increasing input costs. Such price fluctuations create financial uncertainty, as farmers cannot predict the affordability or availability of essential inputs. This unpredictability discourages timely investments, which are crucial for maintaining productivity and managing climate risks. As input costs rise unpredictably, profit margins shrink, impacting on the overall financial health of firms.

In response to these challenges, some farmers and firms in Zambia have started adopting climate-smart agricultural practices, such as conservation farming and crop diversification (Kalinda et al., 2017). While these strategies can reduce vulnerability, they often require initial investments and access to new technologies, which are limited by financial constraints. The high costs and uncertain returns associated with climate-smart practices can deter adoption, especially among smallholder farmers. Without adequate financial support or risk mitigation mechanisms, many are unable to implement these adaptive strategies effectively, perpetuating their vulnerability to climate shocks.

Government interventions and international aid programs have sought to address climate-related financial risks in Zambia, through initiatives like drought relief funds and insurance schemes (Siatwiinda et al., 2021). However, coverage remains limited, and many farmers lack awareness or access to these programs. The low penetration of financial instruments such as weather-indexed insurance means that most farmers are unprotected against extreme events, leaving them exposed to catastrophic losses. Improving awareness, reducing costs, and expanding coverage are essential steps to enhance the sector's resilience and protect farmers' livelihoods (Okamura et al., 2024). Moreover, the limited access to affordable credit hampers farmers' ability to invest in adaptive measures such as improved irrigation, soil conservation, or climate-resilient seeds (Hamazakaza et al., 2022). Many farmers are forced to rely on informal borrowing channels with high interest rates, which further diminishes their net income. Strengthening financial institutions' capacity to provide tailored credit products aligned with climate risks is vital for fostering resilience. Financial support systems specifically designed for climate adaptation can enable farmers to withstand shocks and sustain long-term productivity.

On a broader scale, climate variability influences the macroeconomic stability of Zambia's agricultural sector, impacting exports, employment, and rural development (Tembo et al., 2020). Reduced yields and increased costs led to lower export revenues and diminished foreign exchange earnings. Rural employment is also affected, as farmers are forced to reduce labour or abandon farming altogether during severe climate events. These economic repercussions highlight the importance of integrating climate resilience into national development strategies to ensure sustainable growth and food security amid changing environmental conditions.

It can be noted that climate variability poses significant financial risks for Zambia's agricultural sector, affecting profitability, operational costs, and long-term growth prospects. Addressing these challenges requires a comprehensive approach that combines improved infrastructure, innovative financing, climate-smart practices, and enhanced risk management tools. Strengthening farmer capacity and expanding access to supportive policies can help buffer the sector from climate shocks. As climate change intensifies, proactive measures are essential to safeguard livelihoods, ensure sector resilience, and promote sustainable economic development in Zambia's agriculture.

Empirical evidence from regions outside of Africa, such as China and the United States, demonstrates that climate change risks have a significant negative impact on the profitability of agricultural firms (Liu et al., 2020; Lobell et al., 2016). Crop failures resulting from droughts, floods, and extreme temperatures lead to substantial reductions in yield and revenue, directly eroding profit margins (IPCC, 2022).

Studies have shown that firms operating in high-risk climatic zones experience greater profit volatility and lower returns on investment compared to those in more stable regions (Pankratz et al., 2023). The cumulative effects of repeated climate shocks can also undermine long-term financial sustainability, as firms struggle to maintain profitability and reinvest in productivity-enhancing measures (Lobell et al., 2008). Moreover, the rise in operational costs driven by climate change, such as increased expenditures on irrigation, pest control, and infrastructure repairs, further squeeze profit margins (Deressa et al., 2009). Firms that are unable to effectively manage these cost pressures often see a significant decline in their profitability (Pourzand et al., 2020).

The impact of climate change on profitability is particularly pronounced in regions with high agricultural dependence, such as parts of Asia and Latin America. Studies in these regions have found that increased exposure to climate-related risks, including droughts, floods, and temperature extremes, can lead to substantial reductions in crop yields and revenue, directly eroding the profit margins of agricultural firms (Gaur & Verma, 2023; Khalfaoui et al., 2024). Larger agricultural enterprises with greater financial resources and technological capacity may be better positioned to withstand the profitability impacts of climate change, as they can invest in adaptive strategies such as irrigation systems and drought-resistant crops (Alam et al., 2020). However, smallholder farmers and resource-constrained firms often lack the means to effectively manage these risks, leading to a disproportionate decline in their profitability (Intan et al., 2024).

The literature also highlights the role of market integration and price stability in determining the profitability outcomes of crop diversification strategies (Liu et al., 2020). Firms that can effectively diversify their production and access stable markets may be better able to maintain profitability in the face of climate-related shocks (Cristea et al., 2024). Future research in regions outside of Africa should focus on developing comprehensive frameworks that integrate environmental risk modelling, financial cost-benefit analysis, and firm-level heterogeneity to identify the most effective adaptation strategies and their impact on profitability (Auci et al., 2021). Such interdisciplinary approaches would provide valuable insights to guide policy interventions and support the long-term financial sustainability of agricultural enterprises.

Across Africa, the impact of climate change risks on the profitability of agricultural firms has been well-documented. Studies in countries like Nigeria and South Africa have found that increased exposure to droughts, floods, and extreme temperatures significantly reduces profit margins and undermines the long-term financial viability of agricultural enterprises (Wahab et al., 2024; Mthembu & Zwane, 2017). Crop failures and yield reductions driven by climate variability are a major contributor to the decline in profitability (Siatwiinda et al., 2021). Firms operating in high-risk climatic zones experience greater profit volatility and lower returns on investment compared to those in more stable regions (Mulungu

et al., 2024). The inability to maintain consistent revenue streams due to unpredictable weather patterns further exacerbates the profitability challenges faced by African agricultural firms (Tembo et al., 2020).

Additionally, the rise in operational costs associated with climate change, such as increased expenditures on irrigation, pest control, and infrastructure repairs, significantly erode profit margins in the African agricultural sector (Deressa et al., 2009). Smallholder farmers and cooperatives often lack the financial resources to effectively manage these cost pressures, leading to a disproportionate decline in their profitability (Kazungu, 2024).

The impact of climate change on profitability is especially acute in regions of Africa with high agricultural dependence and limited adaptive capacity. Studies in sub-Saharan Africa have found that the combination of climate-related risks, such as droughts and floods, and structural constraints, such as poor infrastructure and limited access to credit, can severely undermine the profitability of agricultural firms (Makondo & Thomas, 2024; Mulungu et al., 2024). Institutional frameworks and policy interventions play a crucial role in mediating the relationship between climate risks and profitability in the African context. Effective government support, access to climate finance, and the promotion of sustainable agricultural practices can enhance the adaptive capacity of firms and mitigate the profitability impacts of climate change (Tembo et al., 2020; Chanda et al., 2025).

However, the literature suggests that the effectiveness of these interventions is often hindered by institutional challenges, such as bureaucratic inefficiencies and limited reach, particularly in reaching smallholder farmers and cooperatives (Kazungu, 2024). Addressing these institutional barriers will be critical for strengthening the profitability and long-term financial sustainability of the agricultural sector in Africa. Future research in the African context should focus on developing integrated frameworks that combine environmental risk modelling, financial analysis, and policy evaluation to identify the most effective strategies for enhancing the profitability of agricultural firms under climate change conditions (Auci et al., 2021). Such interdisciplinary approaches would provide valuable insights to guide evidence-based policymaking and support the financial resilience of the agricultural sector across the continent.

In Zambia, the impact of climate change risks on the profitability of agricultural firms has been a significant concern. Studies have shown that increased exposure to droughts, floods, and extreme temperatures has a substantial negative effect on the profit margins of agricultural enterprises in the country (Siatwiinda et al., 2021; Okamura et al., 2024; Tembo et al., 2020). Crop failures and yield reductions driven by climate variability are a major contributor to the decline in profitability of Zambian agricultural firms (Chilambwe et al., 2022). Firms operating in high-risk climatic zones, such as Kabwe District, experience greater profit volatility and lower returns on investment compared to those in more stable regions (Mulungu et al., 2024). The inability to maintain consistent revenue streams due to unpredictable weather patterns further exacerbates the profitability challenges faced by agricultural firms in Zambia (Hamazakaza et al., 2022).

Moreover, the rise in operational costs associated with climate change, such as increased expenditures on irrigation, pest control, and infrastructure repairs, significantly erode profit margins in Zambia's agricultural sector (Kalinda et al., 2017). Smallholder farmers and cooperatives, which dominate the agricultural landscape in Zambia, often lack the financial resources to effectively manage these cost pressures, leading to a disproportionate decline in their profitability (Mundia et al., 2022). The profitability challenges faced by Zambian agricultural firms are further compounded by structural constraints, such as limited access to credit, technology, and markets (Malambo, 2019; Maluti & Kabwe, 2025). These factors, combined with the impacts of climate change, create a complex web of challenges that undermine the long-term financial viability of the agricultural sector.

Institutional support and policy interventions have the potential to mitigate the profitability impacts of climate change in Zambia, but the effectiveness of these measures remains limited (Nkhuwa, 2024). Barriers such as bureaucratic inefficiencies, inadequate funding, and weak extension services constrain the ability of agricultural firms to access the necessary resources and support for enhancing their adaptive capacity and profitability (Hamazakaza et al., 2022). Future research in the Zambian context should focus on developing comprehensive frameworks that integrate environmental, economic, and policy analysis to identify the most effective strategies for improving the profitability of agricultural firms under climate change conditions (Auci et al., 2021). This would involve quantifying the cost-effectiveness of adaptation measures, evaluating the impact of institutional support, and addressing the heterogeneous needs of different farm types and ownership structures. Addressing the profitability challenges faced by Zambian agricultural firms is crucial for ensuring the long-term sustainability and growth of the sector, which is a vital contributor to the country's economy and food security. The insights gained from such research would provide valuable guidance for policymakers and development partners in crafting targeted interventions that strengthen the financial resilience of the agricultural sector in the face of climate change.

The literature review has highlighted several key gaps in the existing research on the effects of climate change risks on the financial performance of agricultural firms, particularly in the context of Zambia.

First, there is a limited focus on firm-level analysis, as much of the existing research has concentrated on the impact of climate change on agricultural productivity and household-level outcomes, with limited examination of the direct financial implications for agricultural firms. While studies have explored the effects of climate variability on crop yields and farm incomes (Siatwiinda et al., 2021; Chilambwe et al., 2022), there is a dearth of research that directly investigates how these environmental factors translate into changes in profitability, liquidity, and long-term financial sustainability at the enterprise level (Auci et al., 2021; Pastor-Sanz et al., 2025). For instance, Mulungu et al. (2024) examined the impact of climate change on revenue volatility across agricultural firms in Zambia but did not delve into the specific financial performance metrics and their implications for business operations and investment decisions.

Second, most studies have focused on short-term yield reductions and immediate financial shocks, without adequately addressing the long-term economic implications for firm survival, debt accumulation, and investment constraints. This lack of a long-term perspective is a significant gap in the literature, as the cumulative effects of repeated climate-related disruptions can undermine the viability of agricultural enterprises and their ability to invest in productivity-enhancing measures (Lobell et al., 2008; Mulungu et al., 2024). Existing studies have highlighted the immediate profitability impacts of climate shocks (Tembo et al., 2020; Okamura et al., 2024) but have not explored how these shocks may lead to debt burdens, underinvestment, and ultimately, firm exit over an extended time horizon.

Third, there is insufficient understanding of how climate change risks differentially affect agricultural firms of varying sizes, ownership structures, and levels of diversification. This heterogeneous risk exposure leaves gaps in the development of targeted policy and support interventions (Alam et al., 2020; Liu et al., 2020). Smallholder farmers and resource-constrained enterprises may face disproportionate challenges compared to larger, more diversified firms, but the existing literature does not adequately capture these nuances (Kazungu, 2024; Mundia et al., 2022). For example, Mthembu and Zwane (2017) found that climate change impacts were more severe for small-scale farmers in South Africa but did not explore how these effects may differ for medium or large-scale agricultural enterprises.

Fourth, the literature lacks comprehensive models that integrate environmental risk modelling with financial cost-benefit analysis to determine the most effective adaptation strategies and their impact on profitability and financial performance. The absence of such integrated financial-risk frameworks is a critical gap, as it limits the ability to quantify the long-term viability and cost-effectiveness of various climate change mitigation and adaptation measures (Auci et al., 2021; Pastor-Sanz et al., 2025). Existing studies have focused on the financial impacts of climate change (Wahab et al., 2024; Siatwiinda et al., 2021) but have not developed holistic frameworks to evaluate the trade-offs and synergies between environmental, economic, and financial factors in the context of agricultural adaptation.

Fifth, the role of institutional frameworks, climate finance readiness, and policy interventions in mediating the relationship between climate risks and financial performance remains underexplored, particularly in the context of Zambia. This gap limits the understanding of the effectiveness of support systems in enhancing the adaptive capacity and financial sustainability of agricultural enterprises (Tembo et al., 2020; Chanda et al., 2025). For instance, while Hamazakaza et al. (2022) highlighted the importance of institutional support for Zambian farmers, they did not examine how such interventions may influence the financial performance of agricultural firms in the face of climate change.

Finally, the potential for cooperative structures to enhance the financial resilience of smallholder farmers has been identified, but the specific governance challenges and performance outcomes require further investigation. Addressing this gap in cooperative governance and resilience is crucial for strengthening the financial performance of the agricultural sector, as cooperatives play a significant role in Zambia's agricultural landscape (Mundia et al., 2022; Kayama, 2025). Existing studies have suggested the benefits of cooperative models (Kazungu, 2024) but have not delved into the operational and financial dynamics that enable or constrain their ability to effectively manage climate-related risks.

Addressing these gaps will require interdisciplinary research that combines environmental science, agricultural economics, and business performance analysis to develop a holistic understanding of the complex interactions between climate change, adaptive capacity, and the financial sustainability of agricultural firms in Zambia. Such an approach would provide valuable insights to guide policy interventions and support the long-term growth and resilience of the agricultural sector. This chapter has provided a comprehensive review of the literature on the relationship between climate change risks and the financial performance of agricultural firms, with a focus on the Zambian context. The review has highlighted the significant impact of climate variability, including droughts, floods, and extreme temperatures, on both revenue generation and operational cost structures, thereby influencing profitability, liquidity, and long-term sustainability.

The findings from outside Africa, Africa, and Zambia demonstrate the pervasive nature of these climate-related financial risks, with smallholder farmers and resource-constrained enterprises being the most vulnerable. The review also underscores the critical role of adaptive capacity, institutional support, and climate finance readiness in mediating the financial implications of climate change. Despite the substantial body of research, significant gaps remain in understanding the long-term economic impacts, heterogeneous risk exposure, and the effectiveness of adaptation strategies in the context of Zambia's agricultural sector. Addressing these gaps will require interdisciplinary research that integrates environmental, economic, and business performance analysis to inform evidence-based policy interventions and strengthen the financial resilience of agricultural firms.

The insights gained from this literature review provide a solid foundation for the empirical investigation to be conducted in the subsequent chapters, which will focus on the effects of climate change risks on the operational costs, financial performance, and profitability of agricultural firms in Kabwe District, Zambia.

2.4 Theoretical Framework

The Resource-Based View (RBV)

The study will be anchored on two complementary theories: The Resource-Based View (RBV) of the firm and the Institutional Theory.

The Resource-Based View (RBV) posits that firms achieve competitive advantage and superior performance by effectively managing and deploying their internal resources, including financial, technological, and human capital (Barney, 1991). In the context of agriculture, climate change risks threaten critical resources such as land productivity, water availability,

and labour efficiency, thereby undermining firms' ability to sustain profitability. RBV emphasizes that firms must develop adaptive capabilities such as climate-resilient technologies and financial risk management practices to maintain performance under environmental uncertainty.

Institutional Theory

These institutional theories explain how organizational or social structures and processes acquire meaning and continuity beyond their technical goals. (Suddaby, 2010). Institutional theory itself is concerned about the processes by which formal and informal structures, including schemes, rules, norms and routines, become established as authoritative guidelines for social behavior (Suddaby, 2010; Munir, 2015; Willmott, 2015; Peters, 2022). Institutional theory explains how structures are created, diffused, adopted, adapted, and how they fall into decline and disuse over time (Scott, 2005). Understanding climate change risks in the context of formal and informal institutions is important because institutional factors such as enduring rules, practices, law and structures can influence agricultural organisation's decision making and also influence how they engage with formal financial services. It can influence organisations' decision on how to access formal financial services, and it can have positive or negative implications for the level of financial inclusion in society.

Institutional Theory explains how formal and informal institutions shape financial inclusion by influencing access to and use of financial services in turbulent times. Strong institutions such as transparent regulations, effective governance, and legal frameworks enhance trust, reduce risks, and promote broader financial participation. Empirical evidence shows that higher institutional quality correlates with increased financial penetration, accessibility, and usage in climate change risks. This theory underscores the need for policy reforms and institutional strengthening to foster inclusive financial systems and improve banking sector stability during climate change risks Ali et al, (2021). These studies control for the effect of institutional quality on the level of financial inclusion. The emphasis on institutional quality as a control variable in financial inclusion empirical research reflects the need for independent formal institutions that can enforce rules without fear, and carry out their duties fairly and with appropriate legal powers to sanction rule-breakers, in promoting financial inclusion. This theory will especially address research objective one and two in trying to understand the role and the effects of climate change risks on the financial performance of agricultural firms in Zambia. The institutional theory of financial inclusion states that people constantly interact with formal institutions and informal institutions in society, and their constant interaction with these institutions shape their views on whether they need to join the formal financial sector, remain in the formal financial sector, exit the formal financial sector after joining, or never join the formal financial sector.

The institutional theory of financial inclusion assumes that:

- i. some individuals and firms have incomplete information about how to access formal financial services (Ozili, 2020);
- ii. some individuals and firms have incomplete information about the conditions they must meet in order to access formal financial services (Claessens and Tzioumis, 2006);
- iii. some individuals and firms have incomplete information about the constraints and risks they might face when they join the formal financial sector. These constraints or risks include income and ethnic discrimination, the possible loss of one's deposit when a bank fails, high or multiple transaction costs, etc.

Knowing that they have incomplete information about how to access formal finance, this will motivate them to interact with the informal or formal institutions they have trust in, in order to obtain complete information which will form the basis of their decision making to be financially helped in climate risks. Their frequent interaction with these institutions will shape their views on whether they need access to formal financial services and how to access formal financial services. Informal institutions are enduring and unwritten rules, norms or codes of behavior that are created, communicated, shared and enforced by members of society. Often, informal institutions are widely known, they become tradition and tend to be more persistent than formal rules (North, 2005).

Enduring informal institutions are multiple shared standards of acceptable behavior or informal understanding among members of society and which have lasted over many years. Enduring informal institutions are powerful drivers of people's attitude towards formal financial institutions. Informal institutions can reinforce distrust in formal financial institutions, and discourage members from trusting formal financial institutions with their money or savings. Another factor that contributes to this is when there is a strong belief in society that formal financial institutions are self-serving and do not pursue the interest of customers based on past experiences. This can make some societal members feel their money is never safe in banks. It can also make them to avoid formal financial institutions, or make them believe that it will be difficult to obtain basic financial services from formal financial institutions to meet their emergency needs. They will communicate such belief to other members of society, and also pass the information to the future generation. This will lead to mistrust in formal financial institutions, and decrease trust in the formal financial system, thereby making members of society unwilling to join the formal financial sector. This will decrease the level of financial inclusion.

Informal institutions can also reinforce trust in formal financial institutions, and encourage members to trust formal financial institutions with their money or savings in climate change risk times. A factor that contributes to this is when there is a strong belief in society that formal financial institutions bring great benefit to members of society based on past experiences of difficult times. This can make some societal members feel their money is safe in banks. It can make them patronize formal financial institutions, or make them believe that they can obtain basic financial services from formal financial institutions to meet their emergency needs. They will communicate such belief to other members of society, and also pass the information to the future generation. This will lead to trust in formal financial institutions, and increase

trust in the formal financial system, thereby making members of society willing to join the formal financial sector. The integrated framework combines the Resource Based View and Institutional Theory to explain how agricultural firms in Kabwe District respond to climate change risks and how these responses influence financial performance. The Resource Based View argues that firms achieve better performance when they possess valuable and well organised resources that enable them to adapt to environmental challenges (Barney, 1991). These resources include financial capacity, technology, knowledge, and adaptive capabilities that help firms manage climate related disruptions. Institutional Theory adds an external dimension by emphasising that firm behaviour is shaped by regulatory requirements, policy expectations, market pressures, and social norms within the institutional environment (Scott, 2001). When these two perspectives are combined, they show that resilience to climate change depends on both the internal resource base of a firm and the external institutional pressures that influence strategic decisions. This integration forms the basis of the Climate Resilience Resource Institutional Framework, which illustrates how internal capabilities and institutional forces jointly shape the strategies that agricultural firms adopt to manage climate change risks and sustain financial stability.

2.5 Conceptual framework

The conceptual framework of this study integrates the Resource-Based View and Institutional Theory to illustrate how climate change risks affect the financial performance of agricultural firms in Kabwe District, Zambia. The framework identifies climate-related risks as independent variables, financial performance as the dependent variable, and adaptation capacity as the moderating variable. Figure 1 presents the diagrammatic representation of these relationships.

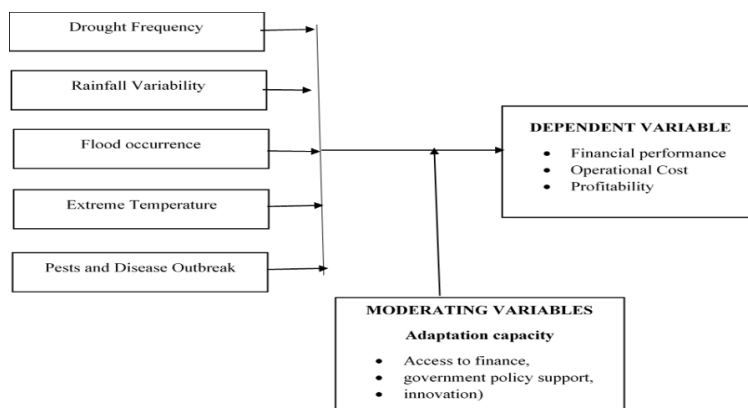


Figure 1: Conceptual Framework

Operationalisation of Variables

The independent variables in this study are the five principal climate change risks to which agricultural firms in Kabwe District are exposed, namely drought frequency, rainfall variability, flood occurrence, extreme temperature, and pest and disease outbreaks. These variables represent the external climate-related stressors that firms must contend with in their day-to-day operations and long-term financial planning. Each of these risks has been documented in the literature as a direct driver of disruption to agricultural production cycles, input costs, and revenue generation, and their combined effect on firm-level financial outcomes forms the central analytical focus of this study. The independent variables act as the primary stimuli within the framework, initiating a chain of financial consequences that ripple through the operational and strategic dimensions of agricultural enterprise.

Independent Variables: Climate Change Risks

Climate change risks represent the primary drivers of financial disruption for agricultural firms in this study. Raza et al. (2019) established that drought frequency, rainfall variability, extreme temperatures, and flood occurrences directly reduce agricultural productivity and escalate operational expenditures across developing economies. Skendžić et al. (2021) further confirmed that climate change intensifies pest and disease pressure, raising the cost of crop protection and undermining firm-level financial stability. The five independent variables examined in this study are therefore drought frequency, rainfall variability, flood occurrence, extreme temperature, and pest and disease outbreaks.

Dependent Variable: Financial Performance

Financial performance captures the economic outcomes achieved by agricultural firms as influenced by climate-related exposures. It is measured in this study through three dimensions, operational costs, profitability, and overall financial sustainability. Brigham and Ehrhardt (2017) noted that climate-induced disruptions simultaneously reduce income and increase expenditure, directly undermining firm viability. Mwaanga and Nkomoki (2021) similarly demonstrated that climate variability threatens the financial performance and sustainability of agricultural enterprises through its compounding effects on revenue and cost structures.

Moderating Variable: Adaptation Capacity (Access to finance, government policy support, and innovation)

Adaptation capacity moderates the relationship between climate change risks and financial performance, reflecting the extent to which a firm can draw on resources and institutional support to cushion itself against climate-induced financial losses. It is measured through three dimensions, access to finance, government policy support, and innovation. Alam et al. (2025) demonstrated that access to financial technology and credit facilities enhances the adaptive capacity of agricultural firms exposed to climate risks. Auci et al. (2021) confirmed that firms investing in innovative technologies and sustainable practices tend to perform better financially under conditions of climate variability, whilst government policy support has been widely recognised as a critical enabler of firm-level climate resilience across sub-Saharan Africa (World Bank, 2021).

Hypotheses Development

Based on the integrated theoretical framework combining the Resource-Based View and Institutional Theory, the following hypotheses are proposed:

Hypothesis 1

H₀₁: Climate change risks have no statistically significant effect on the financial performance of agricultural firms in Kabwe District.

H₁₁: Climate change risks have a statistically significant negative effect on the financial performance of agricultural firms in Kabwe District.

Hypothesis 2

H₀₂: Climate change risks have no statistically significant effect on the operational costs of agricultural firms in Kabwe District.

H₁₂: Climate change risks have a statistically significant positive effect on the operational costs of agricultural firms in Kabwe District.

Hypothesis 3

H₀₃: Climate change risks have no statistically significant effect on the profitability of agricultural firms in Kabwe District.

H₁₃: Climate change risks have a statistically significant negative effect on the profitability of agricultural firms in Kabwe District.

Hypothesis 4

H₀₄: Adaptation capacity, in terms of access to finance, government policy support, and innovation, does not significantly moderate the relationship between climate change risks and the financial performance of agricultural firms in Kabwe District.

H₁₄: Adaptation capacity, in terms of access to finance, government policy support, and innovation, significantly moderates the relationship between climate change risks and the financial performance of agricultural firms in Kabwe District.

3 Research Methodology

To address the research objectives, this study utilized a concurrent convergent parallel design, a mixed methods approach that collects and analyses quantitative and qualitative data simultaneously (Creswell & Plano Clark, 2018). This design was selected to provide a thorough examination of the effects of climate change risks on the financial performance of agricultural firms in Kabwe District, requiring both measurable evidence and contextual insights.

The quantitative strand of the study involved structured questionnaires and statistical techniques, such as regression analysis, to quantify the relationships between climate-related variables and financial performance indicators. This approach aligned with the positivist tradition, allowing for hypothesis testing and the generation of generalizable findings (Saunders, Lewis, & Thornhill, 2019).

Complementing the quantitative component, the qualitative strand included interviews and document reviews to capture the experiences, challenges, and contextual factors that shape the financial resilience of agricultural firms in Kabwe District. This qualitative inquiry provided deeper insights into the institutional frameworks, adaptive strategies, and practical implications that influence the impact of climate change on the financial performance of the agricultural sector. The concurrent convergent parallel design integrated the strengths of both the quantitative and qualitative approaches, allowing for triangulation that enhanced the validity and reliability of the findings (Tashakkori & Teddlie, 2010; Morgan, 2014). This design choice was well-suited to the pragmatist paradigm, as it ensured that the study's results were both scientifically credible and contextually relevant for informing policy and practice in Kabwe District.

By adopting a mixed methods research design, this study was able to generate a comprehensive understanding of the complex relationships between climate change risks and the financial performance of agricultural firms, drawing on both measurable evidence and contextual insights to inform effective interventions and support the long-term resilience of the agricultural sector in Kabwe District. The study population for this research comprises the formally registered agricultural firms operating within Kabwe District, Zambia. According to a report (Kabwe IDP 2022), there are approximately 594 agricultural firms in Kabwe District. Using the Yamane formula (1967), the sample size for the quantitative strand of the study is calculated as follows:

$$n = \frac{N}{(1+N(e)^2)} \text{ Where:}$$

- (n) = sample size
- (N) = population size (594)
- (e) = margin of error (0.05)

The study included a quantitative sample of 239 agricultural firms to ensure adequate representation and generalizable findings, while the qualitative strand involved approximately 20 purposively selected key informants to achieve saturation and capture diverse perspectives. This results in a total sample size of 259 respondents, integrating quantitative breadth with qualitative depth in line with the mixed methods design.

4 Findings

4.1 Climate Factors Influencing the Financial Performance of Agricultural Firms

The first objective sought to identify the specific climate-related factors that influence the financial performance of agricultural firms in Kabwe District. Both descriptive analysis and multiple linear regression analysis were employed, with the same climate risk variables as predictors and overall financial performance as the dependent variable. As presented in Figure 1, respondents were asked to identify the single climate-related factor with the greatest influence on their financial performance. Drought was identified by 72.9% (n = 175) of firms as the primary factor, followed by extreme temperatures at 14.6% (n = 35), floods at 7.1% (n = 17), and pests and diseases at 5.0% (n = 12). This distribution highlights the overwhelming dominance of drought as the climate factor with the greatest perceived influence on financial performance across the sampled firms.

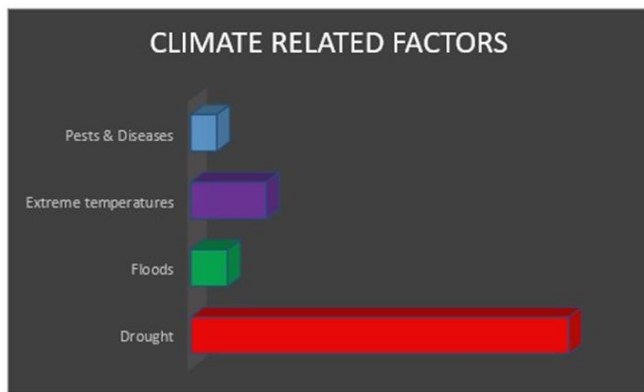


Figure 2: Climate Related Factors

Table 1 presents the model summary for the financial performance regression. The multiple correlation coefficient (R = 0.312) indicates a moderate positive relationship between the combined climate risk variables and financial performance. The Adjusted R-square of 0.387 indicates that the model explains 38.7% of the variation in financial performance after correcting for the number of predictors. The standard error of the estimate (0.847) reflects satisfactory model precision.

Table 1: Model Summary - Financial Performance

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.312 ^a	0.097	0.387	0.847

Source: Survey (2026)

a. Predictors: (Constant), Drought Frequency, Rainfall Variability, Flood Occurrence, Extreme Temperature, Pest and Disease Outbreak (Climate-Induced).

4.2 Effect of Climate Change Risks and Operational Costs of Agricultural Firms

Table 2 presents the model summary for the operational cost’s regression. The multiple correlation coefficient (R = 0.235) indicates a positive relationship between the combined climate risk variables and operational costs. The R-square value of 0.055 suggests that 5.5% of the raw variance in operational costs is attributed to the predictors. The Adjusted R-square of 0.430 indicates that after correcting for the number of predictors, the model explains 43.0% of the variation in operational costs. The standard error of the estimate (0.935) reflects an acceptable level of dispersion around the regression line.

Table 2: Model Summary- Operational Cost

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.235 ^a	0.055	0.430	0.935

Source: Survey (2026)

4.3 Moderating Effect of Adaptation Capacity on the Relationship Between Climate Change Risks and Financial Performance

The table 3 presents the model summary for the moderated regression analysis. Model 1, containing only the main effects, returned an Adjusted R-square of 0.387, consistent with the financial performance regression reported in Section 4.4.2. The introduction of the interaction terms in Model 2 produced a statistically significant R-square change of 0.094 (F change = 3.841, p = 0.012), indicating that adaptation capacity adds significant explanatory power to the model beyond the direct effects of climate risks alone. The Adjusted R-square increased from 0.387 to 0.481, meaning that the moderated model accounts for 48.1% of the variation in financial performance, a meaningful improvement over the main effects model.

Table 3: Model Summary- Moderated Regression (Adaptation Capacity)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	Sig. F Change
1 (Main Effects)	0.312 ^a	0.097	0.387	0.847	0.097	5.124	0.001
2 (Main Effects + Interaction)	0.401 ^b	0.191	0.481	0.801	0.094	3.841	0.012

Source: Survey (2026)

a. Predictors: (Constant), Drought Frequency, Rainfall Variability, Flood Occurrence, Extreme Temperature, Pest and Disease Outbreak

b. Predictors: (Constant), Drought Frequency, Rainfall Variability, Flood Occurrence, Extreme Temperature, Pest and Disease Outbreak, Adaptation Capacity × Drought Frequency, Adaptation Capacity × Rainfall Variability, Adaptation Capacity × Flood Occurrence, Adaptation Capacity × Extreme Temperature, Adaptation Capacity × Pest and Disease Outbreak

4.4 Hypothesis Testing Summary

This section consolidates the outcomes of the hypothesis tests derived from the three regression models presented in Section 4.4, providing a clear and structured account of whether the null or alternative hypotheses were supported by the empirical evidence.

Hypothesis One

H₀₁: Climate change risks have no statistically significant effect on the financial performance of agricultural firms in Kabwe District.

H₁₁: Climate change risks have a statistically significant negative effect on the financial performance of agricultural firms in Kabwe District.

The regression model predicting financial performance was statistically significant overall (F = 5.124, p = 0.001), with extreme temperature as a significant individual predictor ($\beta = 0.268$, p = 0.000). The null hypothesis H₀₁ is therefore rejected and the alternative hypothesis H₁₁ is accepted. Among the specific climate-related factors examined, extreme temperatures exert the most statistically significant and direct negative effect on the financial performance of agricultural firms in Kabwe District

Hypothesis Two

H₀₂: Climate change risks have no statistically significant effect on the operational costs of agricultural firms in Kabwe District.

H₁₂: Climate change risks have a statistically significant positive effect on the operational costs of agricultural firms in Kabwe District.

The regression model predicting operational costs was statistically significant overall (F = 4.559, p = 0.004), and drought frequency was individually significant ($\beta = 0.188$, p = 0.006). On this basis, the null hypothesis H₀₂ is rejected and the

alternative hypothesis H_{12} is accepted. Climate change risks, particularly the frequency of drought events, have a statistically significant positive effect on the operational costs of agricultural firms in Kabwe District.

Hypothesis Three

H_{03} : Climate change risks have no statistically significant effect on the profitability of agricultural firms in Kabwe District.

H_{13} : Climate change risks have a statistically significant negative effect on the profitability of agricultural firms in Kabwe District.

The regression model predicting profitability was statistically significant overall ($F = 4.871$, $p = 0.002$), with both drought frequency ($\beta = 0.201$, $p = 0.008$) and extreme temperature ($\beta = 0.241$, $p = 0.001$) emerging as statistically significant individual predictors. The null hypothesis H_{03} is therefore rejected and the alternative hypothesis H_{13} is accepted. Climate change risks, specifically the compounding effects of drought frequency and extreme temperatures, have a statistically significant negative effect on the profitability of agricultural firms in Kabwe District.

Hypothesis Four

H_{04} : Adaptation capacity, in terms of access to finance, government policy support, and innovation, does not significantly moderate the relationship between climate change risks and the financial performance of agricultural firms in Kabwe District.

H_{14} : Adaptation capacity, in terms of access to finance, government policy support, and innovation, significantly moderates the relationship between climate change risks and the financial performance of agricultural firms in Kabwe District.

The moderated regression model demonstrated a statistically significant R-square change upon introduction of the interaction terms ($\Delta R^2 = 0.094$, F change = 3.841, $p = 0.012$), confirming that adaptation capacity adds significant explanatory power beyond the direct effects of climate risks alone. The adjusted R-square improved from 0.387 in the main effects model to 0.481 in the moderated model, indicating that the inclusion of adaptation capacity accounts for an additional 9.4% of the variation in financial performance. At the individual interaction level, the moderating effect was statistically significant for drought frequency ($\beta = -0.214$, $p = 0.004$) and extreme temperature ($\beta = -0.289$, $p = 0.000$), with negative coefficients confirming that higher adaptation capacity reduces the adverse financial consequences of these two dominant climate hazards. The null hypothesis H_{04} is therefore rejected and the alternative hypothesis H_{14} is accepted. Adaptation capacity, encompassing access to finance, government policy support, and innovation, significantly moderates the relationship between climate change risks and the financial performance of agricultural firms in Kabwe District, with firms possessing stronger adaptive resources experiencing comparatively reduced financial deterioration under climate stress.

5 Conclusions and Recommendations

The study concludes that climate change risks collectively and significantly influence the financial performance of agricultural firms in Kabwe District, with the overall regression model confirming statistical significance ($F = 5.124$, $p = 0.001$) and accounting for 38.7% of the variance in financial performance, leading to the rejection of H_{01} . Among the individual climate risk variables examined, extreme temperature emerged as the most statistically significant specific factor influencing financial performance ($\beta = 0.268$, $p = 0.000$). Temperature-related stress reduces financial performance through multiple simultaneous pathways, including suppressed crop yields, livestock heat stress, reduced labour productivity, and increased pest prevalence, all of which erode revenue whilst leaving or elevating cost structures. Drought was the most frequently perceived threat by firms descriptively, cited by 72.9% of respondents, and its primary influence on financial performance operates through cost escalation rather than as a direct and independently measurable revenue impact at the individual predictor level. Rainfall variability, flood occurrence, and pest and disease outbreaks contribute to the broader climate risk environment but do not individually reach statistical significance, their effects better understood as cumulative and systemic in nature.

Given that extreme temperature has been identified as the most statistically significant individual driver of financial performance deterioration, agricultural firms in Kabwe District are strongly encouraged to prioritise temperature risk in their operational and financial planning. Firms should invest in heat-resistant and drought-tolerant crop varieties capable of maintaining yields under elevated temperature conditions and should adopt shade management and ventilation systems for livestock operations to reduce heat stress losses.

Declaration of Competing Interests

The authors declare that they are not aware of any competing financial interests or personal relationships that may have influenced the work described in this document.

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Ethical considerations

The article followed all ethical standards appropriate for this kind of research.

References

- Alam, A., Banna, H., Roni, N. N., & Abedin, M. Z. (2025). Sowing Sustainability: How does fintech mitigate agricultural financial risk from climate change vulnerability. *International Review of Economics & Finance*, 104226.
- Alam, M. M., Ibrahim, Y., & Mia, M. S. (2020). Climate change impacts on yield and financial performance of agro-plantation companies in Malaysia. *International Journal of Postharvest Technology and Innovation*, 7(1), 15-28.
- Auci, S., Barbieri, N., Coromaldi, M., & Michetti, M. (2021). Climate variability, innovation and firm performance: evidence from the European agricultural sector. *European Review of Agricultural Economics*, 48(5), 1074-1108.
- Chanda, O., Shen, J., & Umetsu, C. (2025). Impact of land tenure security on technical efficiency for maize production: the case of Central province in Zambia. *PLOS Sustainability and Transformation*, 4(8), e0000189.
- Charlton, M., & Danny, M. (2025). Effect of Climate Change on Agricultural Productivity: A Study of Choma District Zambia. *Journal of Agriculture, Aquaculture, and Animal Science*, 2(1), 195-202.
- Chen, S., & Wang, Z. (2025). Climate change and listed agricultural companies' risk-taking. *International Review of Economics & Finance*, 99, 103961.
- Chilambwe, A., Crespo, O., & Chungu, D. (2022). Climate change impacts on maize and soybean yields in Zambia. *Agronomy Journal*, 114(4), 2430-2444.
- Cristea, M., Noja, G. G., Drăcea, R. M., Iacobuță-Mihăiță, A. O., & Dorożyński, T. (2024). ESG investment strategies and the financial performance of European agricultural companies: a new modelling approach. *Journal of Business Economics and Management*, 25(6), 1283-1307.
- De Pinto, A., Smith, V. H., & Robertson, R. D. (2019). The role of risk in the context of climate change, land use choices and crop production: evidence from Zambia. *Climate Research*, 79(1), 39-53.
- Gaur, A., & Verma, S. (2023). Impact of climate change on agriculture. *The Impact of Climate Change and Sustainability Standards on the Insurance Market*, 193-209.
- Hamazakaza, P., Kabwe, G., Kuntashula, E., Egeru, A., & Asimwe, R. (2022). Adoption of sustainable agriculture intensification in maize-based farming systems of Katete district in Zambia. *Land*, 11(6), 880.
- Intan, D. R., Malau, L. R. E., Rambe, K. R., & Damanik, M. (2024). Factors Affecting the Financial Performance of Agricultural Company's: Evidence from the Indonesia Stock Exchange. *Agroeconomics: Jurnal Sosial Ekonomi Pertanian*, 8(2), 457-470.
- Kalinda, T. H., Tembo, G., & Ng'ombe, J. N. (2017). Does adoption of conservation farming practices result in increased crop revenue? Evidence from Zambia. *Agrekon*, 56(2), 205-221.
- Kayama, Y. (2025). Effects of financial management practices on the performance of cooperatives: a case of Kabwe district cooperative union limited (Doctoral dissertation, The university of Zambia).
- Kazancoglu, Y., Lafci, C., Kumar, A., Luthra, S., Garza-Reyes, J. A., & Berberoglu, Y. (2024). The role of agri-food 4.0 in climate-smart farming for controlling climate change-related risks: A business perspective analysis. *Business Strategy and the Environment*, 33(4), 2788-2802.
- Kazungu, M. K. (2024). Effect of Value Chain Financing on the Financial Performance of Agricultural and Manufacturing Firms Listed at the Nairobi Securities Exchange (Doctoral dissertation, University of Nairobi).
- Khalifaoui, R., Goodell, J. W., Mefteh-Wali, S., Chishti, M. Z., & Gozgor, G. (2024). Impact of climate risk shocks on global food and agricultural markets: A multiscale and tail connectedness analysis. *International Review of Financial Analysis*, 93, 103206.
- Leeliang, K., & Terdpaopong, K. (2024, August). Climate Change Impact on the Financial Performance of Listed Agricultural Corporations. In *International Conference on Research in Management & Technovation* (pp. 349-360). Singapore: Springer Nature Singapore.
- Liu, L., Beirne, J., Azhgaliyeva, D., & Rahut, D. (2024). Climate change and corporate financial performance. *Journal of Risk and Financial Management*, 17(7), 267.
- Liu, L., Xu, J., & Shang, Y. (2020). Determining factors of financial performance of agricultural listed companies in China.

- Custos e Agronegocio, 16(4), 297-314.
- Makondo, C. C., & Thomas, D. S. (2024). Multidimensional poverty and vulnerability assessment in the face of climate change adaptation in developing economies: focus on ecosystem-based livelihoods in Zambia. *Environment, Development and Sustainability*, 1-47.
- Malambo, A. H. (2019). Agricultural transformation in Zambia's Chibombo, Kapiri Mposhi and Mumbwa districts, during the periods 1980-1990 and 1997-2008 (Doctoral dissertation, University of Zambia).
- Maluti, D., & Kabwe, M. (2025). An Investigation of Co-operatives in Crop Production as a Tool for Poverty Reduction in Zambia a Case Study of Lufwanyama District. *IJSAT-International Journal on Science and Technology*, 16(1).
- Mbalu, P., & Kamau, C. G. (2022). Corporate Sustainability Accounting and Reporting in Kenya. Available at SSRN 4000715.
- Megeid, N. S. A. (2024). The impact of climate risk disclosure on financial performance, financial reporting and risk management: evidence from Egypt. *Future Business Journal*, 10(1), 21.
- Mulungu, K., Kimani, M. E., & Sarr, M. (2024). Do farmers' risk preferences remain stable in the face of climatic shocks? Evidence from smallholder farmers in Zambia. *Applied Economics*, 56(15), 1784-1800.
- Mundia, M., Nkonde, C., Simui, F., & Imasiku, J. (2022). Exploration of Agriculture Cooperative Enterprising Performance in Kabwe District, Zambia. *World Journal of Research and Review*, 1(5), 5.
- Mzyece, A., & Ng'ombe, J. N. (2020). Does crop diversification involve a trade-off between technical efficiency and income stability for rural farmers? Evidence from Zambia. *Agronomy*, 10(12), 1875.
- Nkhuwa, L. A. U. R. A. (2024). Living the consequences of climate change: opportunities and challenges of climate change adaptation in Zambia. *International Journal of Recent Research in Thesis and Dissertation*, 5(2), 15-33.
- Okamura, S., Miura, K., & Umetsu, C. (2024). Do Zambian Farmers Manage Climate Risks?. *NRE Discussion Papers*, 1.
- Pankratz, N., Bauer, R., & Derwall, J. (2023). Climate change, firm performance, and investor surprises. *Management science*, 69(12), 7352-7398.
- Pastor-Sanz, I., Tascón, M. T., Castro, P., & Amor-Tapia, B. (2025). Impact of physical climate risks on agricultural firms' bankruptcy: evidence from France, Italy, Portugal and Spain from 2016 to 2019. *International Food and Agribusiness Management Review*, 1(aop), 1-20.
- Pourzand, F., Noy, I., & Sağlam, Y. (2020). Droughts and farms' financial performance: a farm-level study in New Zealand. *Australian Journal of Agricultural and Resource Economics*, 64(3), 818-844.
- Sacchelli, S., Fabbrizzi, S., Bertocci, M., Marone, E., Menghini, S., & Bernetti, I. (2017). A mix-method model for adaptation to climate change in the agricultural sector: A case study for Italian wine farms. *Journal of Cleaner Production*, 166, 891-900.
- Sandberg, H., Alnoor, A., & Tiberius, V. (2023). Environmental, social, and governance ratings and financial performance: Evidence from the European food industry. *Business Strategy and the Environment*, 32(4), 2471-2489.
- Sheeraz, M., Iqbal, N., & Sajid, M. (2024). A nexus between climate change risk and financial performance of agricultural businesses in developing economy. In *Climate Change and Finance: Navigating the Challenges and Opportunities in Capital Markets* (pp. 255-278). Cham: Springer Nature Switzerland.
- Siame, M. (2016). Performance of Zambia's co-operatives. A case study of Kabwe, Lusaka and Kafue based co-operatives. *The International Journal of Innovative Research and Development*, 235.
- Siatwiinda, S. M., Supit, I., van Hove, B., Yerokun, O., Ros, G. H., & de Vries, W. (2021). Climate change impacts on rainfed maize yields in Zambia under conventional and optimized crop management. *Climatic Change*, 167(3), 39.
- Sun, Y., Zou, Y., Jiang, J., & Yang, Y. (2023). Climate change risks and financial performance of the electric power sector: Evidence from listed companies in China. *Climate Risk Management*, 39, 100474.
- Tembo, B., Sihubwa, S., Masilokwa, I., & Nyambe-Mubanga, M. (2020). Economic implications of climate change in Zambia. Lusaka, Zambia.
- Thai, H. M., Nguyen Thuc Huong, G., Nguyen, T. T., Pham, H. T., Nguyen, H. T. K., & Vu, T. H. (2024). Impacts of climate change risks on financial performance of listed firms in agriculture industries in Vietnam. *Journal of Agribusiness in Developing and Emerging Economies*, 14(5), 937-957.
- Vasile, B., & Camelia, B. (2017). Financial Performance and The Business Risk in Agricultural Sector of Romania. (3).

- Vuković, B., Milutinović, S., Mijić, K., Krsmanović, B., & Jaksic, D. (2022). Analysis of financial performance determinants: evidence from the European agricultural companies. *Custos e agronegócio*, 18(1), 285-306.
- Wahab, F., Khan, M. J., Khan, M. Y., & Mushtaq, R. (2024). The impact of climate change on agricultural productivity and agricultural loan recovery; evidence from a developing economy. *Environment, Development and Sustainability*, 26(10), 24777-24790.