Int. j. adv. multidisc. res. stud. 2026; 6(1):1951-1959

Received: 17-12-2025
Accepted: 27-01-2026

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Examining the Effects of Drought on Household Food Security Among Small - Scale Farmers: A Case Study of Musyani Ward, Nakonde District

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DOI: https://doi.org/10.62225/2583049X.2026.6.1.5756
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Abstract

This study examines the effects of drought on household food security among small- scale farmers: a case study of Musyani ward, Nakonde District. This is done by using a mixed- approach, (qualitative and quantitative) data from 50 farmers aged 30-70 as qualitative insights were collected through questionnaires and interviews. The investigation assessed the effects of climate change on crop yields among small scale famers, evaluated the climate change adaptation strategies employed by small scale farmers, and identified recommendations to enhance household food security in Nakonde District, Zambia.

The findings reveal that drought is a frequent and recurring challenge in Nakonde, with 30.7% of farmers experiencing drought annually and 35.09% every 2-3 years. Deforestation was identified as a major exacerbating factor for drought severity by 70.31% of respondents. Droughts significantly reduced maize yields, with 28.07% reporting substantial decreases over five years and 64% observing marked reductions in crop quality last season. The resultant water scarcity, reduced yields, increased pest incidence, soil degradation, and crop failures have severely affected agricultural productivity and household incomes, with 65% experiencing significant financial losses. Importantly, all farmers reported increased stress and anxiety linked to drought conditions by impacting social cohesion and mental health.

However, 26.32% of the respondents employed Adaptation strategies which include irrigation system while 25.44% adopted crop rotation and 20.18% uses drought-resistant varieties. 27.19% of the respondents face challenges such as lack of advanced technology and financial constraints which constitute 21.05% of the respondents as 17.54% of the respondents said the resource scarcity were impede effectiveness.

Discussion highlights the intertwined environmental, socio-economic, and psychological effects of climate change on Nakonde' s small-scale farmers. The study emphasizes the urgent need for integrated interventions including financial support, capacity-building, improved water management infrastructure, reforestation, mental health services, and inclusive policies. Not only this but also strengthening local institutions and leveraging indigenous knowledge alongside modern practices were recommended to enhance adaptive capacity.

Keywords: Drought, Climate Change, Food Security, Small Scale Farmers, Agricultural Productivity, Crop Yields, Adaptation Strategies, Vulnerability and Rain-Fed Agriculture

1. Introduction

1.1 Background of the Study

Zambia, like many countries in Sub-Saharan Africa, faces severe challenges from climate change, particularly concerning food security. As drought intensifies globally, its impacts on agriculture especially in rain-fed farming systems have become more evident. The region's vulnerability is heightened by limited adaptive capacity, making food security a growing concern. Drought-induced hazards such as droughts, floods, soil erosion, pests, and diseases disrupt agricultural productivity, directly threatening both livelihoods and national food systems (Osuafor, 2022). Zambia's Strategic Plan for Agriculture and Rural Statistics (2019–2023) outlines the Ministry of Agriculture's goal of achieving sustainable and diversified food systems. However, climate variability continues to undermine this mission, contributing to food shortages and malnutrition.

Drought disproportionately affects smallholder farmers, who make up the bulk of Zambia's agricultural workforce and are highly dependent on rain-fed agriculture. As a result, these farmers are both food producers and consumers, making them

extremely susceptible to climate shocks. Reports indicate that Zambia has experienced increased frequency and intensity of droughts and erratic rainfall, leading to lower maize yields the country's staple crop (Zambia Meteorological Department, 2023). Studies in Nakonde District have shown that climate variability has caused severe reductions in crop yields, food price surges, and increased dependence on food aid (Mulenga *et al*., 2022). Furthermore, unsustainable farming practices and deforestation have contributed to soil degradation, further compounding the problem.

Global efforts, including Sustainable Development Goal 2 (SDG 2), advocate for ending hunger and promoting sustainable agriculture. However, these goals remain distant for Zambia's rural farmers due to persistent socio-economic barriers. Women and youth are particularly affected, as gender inequalities limit their access to land, resources, and decision-making power. Although the government has introduced initiatives such as the National Climate Change Response Strategy and promoted conservation agriculture, the uptake remains limited. Many farmers lack financial resources, technical support, and access to climate-resilient technologies (Zambia Agriculture Research Institute, 2023).

The broader African and global context also reflects similar trends. For instance, studies project significant declines in staple crop yields worldwide if climate trends continue, with smallholder farmers in Africa facing heightened vulnerability due to reliance on rainfall and limited infrastructure (Wheeler & Von Braun, 2022). In Zambia, rural poverty, poor road networks, and market isolation hinder farmers' ability to adapt. In districts like Nakonde, these challenges are particularly pronounced, with many households struggling to cope with rising food prices and frequent crop failures.

In summary, the intersection of drought, agriculture, and socio-economic vulnerabilities poses a serious threat to food security in Zambia. Understanding the adaptive strategies used by smallholder farmers and the socio-economic factors that influence their resilience is critical for developing effective responses. The case of Nakonde District illustrates the urgent need for targeted interventions that address both environmental and structural barriers to food security.

1.2 Statement of the Problem

During the 2023/2024 season, national maize production collapsed from approximately 3,261,685 metric tons in 2023/2022 to 1,511,143 metric tons declined of about 54% (DMMU, 2024). Thus, despite the scale of the crisis and the known risks, there is still knowledge gap.

Drought poses a serious threat to agricultural productivity and food security among small-scale farmers in Nakonde District, Zambia. These farmers rely heavily on rain-fed agriculture, particularly maize cultivation and livestock rearing, to sustain their livelihoods. However, their ability to produce enough food is being increasingly disrupted by changing weather patterns, including erratic rainfall, prolonged droughts, and extreme weather events. These climate-induced challenges have led to reduced crop yields, food shortages, and declining household incomes.

Although government efforts such as subsidies and climate-smart agriculture policies aim to improve resilience, there is limited empirical evidence on their effectiveness in Nakonde District. Traditional farming practices that could enhance resilience are also under-researched in the local context. The 2019 Zambia Integrated Food Security Phase Classification (IPC) report highlights acute food insecurity and poor agricultural production in the country, underscoring the urgency of localized assessments. Furthermore, vulnerable groups, especially older small-scale farmers aged 30–70, are disproportionately affected due to their dependence on subsistence farming.

Despite national efforts to address the impacts of climate change, specific data on how it affects food security in Nakonde District is scarce. Therefore, this study seeks to examine the extent and nature of climate change impacts on food security among small-scale farmers in this region. The findings will contribute to evidence-based interventions aimed at improving food security and building climate resilience at the local level.

1.3 General Objectives

To examine the effects of drought on agricultural productivity and food security among small-scale farmers in Musyani ward, Nakonde District.

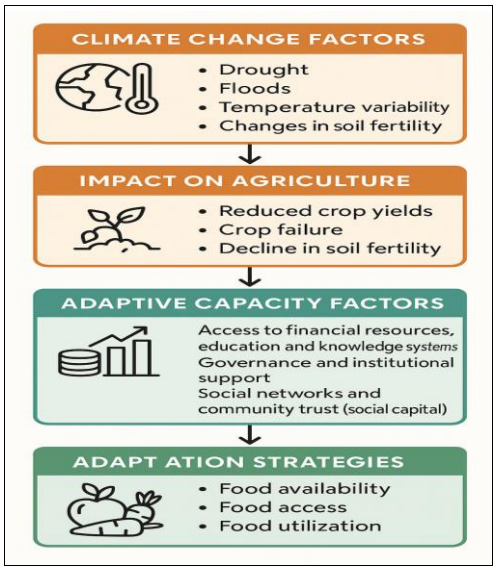
1.3.1 Specific Objectives

1. To identify the drought copying and adaptation strategies employed by small scale farmers in musyani ward, Nakonde District.
2. To determining the effectiveness of the copying and adaptation strategies used by the small- scale farmers to enhance food security in Musyani Ward, Nakonde District.
3. To identify the limitations of the drought copying and adaptation strategies employed by the small- scale farmers in Musyani ward, Nakonde District.

1.4 Research Questions

1. What drought copying and adaptation strategies are employed by small scale farmers in musyani ward, Nakonde District?
2. How effective are the drought copying and adaptation strategies employed by the small -scale farmers in enhancing food security in Musyani Ward, Nakonde District?
3. What are the limitations of the drought copying and adaptation strategies used by the small- scale farmers in Musyani ward, Nakonde District?

1.5 Conceptual Framework



This framework has provided a valuable lens for assessing the effects of drought on household food security among small scale farmers in Musyani ward, Nakonde District, Zambia. The Adaptation Framework is outlined by (Adger, *et al* 2020), highlights the varying exposure and sensitivity of individuals, small scale farmers, and communities to drought-related disturbances, as well as their capacity to adapt.

In this context, Food security is the dependent variable because it represents the final outcome affected by drought and agricultural performance. When drought conditions worsen and agricultural productivity declines, the availability, access, and utilization of food also deteriorate, leading to increased food insecurity among small-scale farmers.

However, drought is considered the independent variable because it is the main external condition influencing other aspects of the farming system particularly agricultural productivity and food security. Agricultural Performance as Intermediate Variable: The intermediate variable also referred to as the mediating variable. This variable explains the pathway through which drought affect food security. It represents the direct consequences of drought on farming outcomes such as crop yield, soil fertility, and overall agricultural output.

1.6 Significance of the Study

The study on the Examining the effects of drought on household food security among small scale farmers aged (30-70) in Nakonde District, Zambia is crucial given the increasing threat that climate change poses to agriculture-dependent regions. Climate-related disruptions, such as erratic rainfall and prolonged droughts, directly impact food production and availability, placing rural communities at heightened risk (Ahmed and Lorica, 2017). Nakonde District, with its reliance on agriculture, is particularly vulnerable to these changes. Understanding how climate change affects food security in this region is essential for developing targeted strategies that protect vulnerable farmers from food shortages and mitigate broader climate factors (Bene *et al*., 2016). This research also fills a critical gap in district-level studies on climate change and food security in Zambia. While national and global reports highlight the general effects of climate change, localized data on marginalized groups remain limited. By focusing on small scale farmers in Nakonde, this study will provide evidence-based recommendations for policymakers and organizations involved in climate adaptation and food security initiatives. The findings will not only inform immediate intervention strategies also contribute to a deeper understanding of the long-term effects of climate change on food systems and rural livelihoods which serves as a foundation for future research and policy development (Brummet & Williams, 2019).

1.7 Scope of the Study

The scope of this study focuses on assessing the effects of climate change on food security among small –scale farmers in Nakonde District, Zambia. It will examine the specific ways in which climate-induced changes, such as shifting rainfall patterns, droughts, and temperature fluctuations, affect agricultural productivity, food availability, and access to food for this demographic. The study will also analyze how socioeconomic factors, including limited resources, traditional farming practices, and adaptive capacity, influence the ability of individual's small scale farmers to cope with climate variability and secure their food needs. Geographically, the research will be confined to Nakonde District, which is characterized by its reliance on agriculture and vulnerability to environmental changes (Ebi *et al*, 2017). The study will employ both qualitative and quantitative methods to gather data from local farmers, in the district. By focusing on this specific population and region, the study aims to provide a detailed, localized understanding of climate change impacts on food security, while also exploring potential adaptive strategies that could be implemented to mitigate these effects. The findings will be relevant to policymakers, local governments, and development organizations working to improve food security and climate resilience in Zambia.

2. Literature Review

Drought is projected to significantly affect agricultural production worldwide, affecting crop yields and food security. Globally, maize yields are expected to decline by up to 24% by the end of the century due to rising temperatures and altered precipitation patterns (IPCC, 2019). In contrast, wheat yields may increase by about 17% in temperate regions, as cooler temperatures and increased CO2 levels can enhance growth under certain conditions (Lobell & Burke, 2023). However, the impact of climate change varies by region, with tropical areas experiencing more severe yield declines due to higher temperatures already near or past optimal levels for many crops (Schmidhuber & Tubiello, 2021).

Increased CO2 levels can benefit some crops through carbon fertilization, but this effect is often offset by temperature-related stress and altered precipitation patterns (Long *et al*., 2018). For example, while increased CO2 can enhance photosynthesis and growth in some crops, droughts and heatwaves can negate these benefits by limiting water availability and causing heat stress (Ziska *et al*., 2016). Furthermore, climate change is projected to increase the frequency and severity of extreme weather events such as floods and droughts, which can devastate agricultural production and lead to food shortages (Mendelsohn *et al*., 2017).

3. Research Methodology

3.1 Overview

This study employed a mixed-methods approach to examine the effects of drought on food security among small-scale farmers in Nakonde District, Zambia, while suggesting potential solutions to mitigate identified challenges. The methodology outlined the research design, study setting, target population, sampling procedures, data collection methods, data analysis techniques, triangulation strategies, and ethical considerations.

3.2 Research Design

A mixed-methods cross-sectional design was employed. Quantitative data were collected using structured questionnaires to measure agricultural productivity, food availability, and household income. Qualitative insights were obtained through semi-structured interviews and focus group discussions to explore farmers' adaptation strategies and experiences. This design allowed for the identification of relationships between climate variables and food security

indicators while generating solution-oriented insights (Mwale *et al*., 2020).

3.3 Sampling Techniques
Both probability and non-probability sampling methods were utilized. Judgmental sampling was applied due to time and resource constraints, enabling the selection of farmers with relevant experiences. Stratified random sampling was then used to ensure representation of vulnerable groups such as elderly farmers, people with chronic illnesses, and pregnant women. A total of 50 small-scale farmers participated in the study (McDaniel & Gates, 2023; Malhotra & Birks, 2016).

3.4 Sample Size Determination
The sample size of 50 participants was determined using Slovin's formula. This number enabled adequate statistical analysis while allowing exploration of qualitative aspects, particularly among vulnerable sub-groups such as elderly farmers and women-headed households (Morgan *et al*., 2019). The final sample remained subject to financial constraints.

3.5 Target Population
The target population comprised vulnerable small-scale farmers aged 30–70 in Nakonde District, including elderly individuals, farmers with chronic conditions, and pregnant women. These groups were more susceptible to climate-related food insecurity due to health limitations, economic constraints, and heightened nutritional needs (Moyo *et al*., 2020).

3.6 Data Collection Method
Data were collected using a structured, self-administered questionnaire. The instrument contained closed-ended questions, Likert-scale items, and multiple-choice questions to capture knowledge of climate change, food security practices, and adaptation behaviors. This tool facilitated standardized data collection and enabled solution-focused assessment of local adaptive capacity (Creswell *et al*., 2020; Kothari, 2018).

3.7 Study Setting
The study was conducted in Nakonde District in northern Zambia, an area heavily dependent on rain-fed agriculture and highly vulnerable to erratic rainfall and drought. This setting provided a relevant context for examining climate-related food insecurity and identifying locally appropriate adaptation strategies.

3.8 Data Analysis
Collected data were cleaned, coded, and entered into SPSS version 29. Descriptive statistics generated frequencies and percentages. Chi-square tests assessed associations between categorical variables at a significance level of $p < 0.05$. Multivariate logistic regression examined relationships between demographic variables and food security outcomes, generating odds ratios and confidence intervals. Findings were presented in tables, charts, and graphs.

3.9 Triangulation
Methodological triangulation enhanced validity by integrating data from different sections of the structured questionnaire. This facilitated a more comprehensive understanding of the relationship between drought and food security while supporting the identification of practical, evidence-based solutions.

3.10 Limitations of the Study
The study faced several limitations. Response bias may have occurred due to socially desirable responses, especially regarding climate-related behaviors (ChishtyM, 2021). The exclusive use of structured questionnaires limited the depth of qualitative insights. Additionally, the findings were context-specific and may not be generalizable to other regions with different socio-economic and environmental conditions.

3.11 Ethical Considerations
Ethical approval was obtained from ICUBREC, Nakonde City Council, and the Nakonde District Agriculture Office. Participation was voluntary, and informed consent was secured before data collection. No personal identifiers were collected, ensuring anonymity. All data were stored securely and accessed only by the researcher. Participants were informed of their right to withdraw at any time without consequence.

4. Research Findings
4.0 Overview
This chapter presents and discusses the findings of the study in relation to the research objectives. The presentation of the empirical findings and discussion based on the descriptive analysis of the data collected from various participants. The study core objective was to examine the effects of climate change on small-scale farmers in Nakonde District of Zambia. The following are specific research objectives that inspired the study:

To identify the drought copying and adaptation strategies employed by small scale farmers in musyani ward, Nakonde District.

To determining the effectiveness of the copying and adaptation strategies used by the small- scale farmers to enhance food security in Musyani Ward, Nakonde District.

To identify the limitations of the drought copying and adaptation strategies employed by the small- scale farmers in Musyani ward, Nakonde District.

The following illustrates responses and interpretations in line with questions respondents managed to attempt to. The questions will be aligned as well as the responses for each, in addition this shall by accompanied with graphs, pictures, histograms and other visual presentation content.

4.0 Overview
This chapter explains about the background characteristics of the respondents, presentation of the results based on the thematic area of first objective, Presentation of the results based on the thematic area of the second objective, Presentation of results based on third objective and discussion of the research findings. The study was guided by the following Specific Objectives: To identify the drought copying and adaptation strategies employed by small scale farmers in musyani ward, Nakonde District, to determining the effectiveness of the copying and adaptation strategies used by the small- scale farmers in enhancing food security in Musyani Ward, Nakonde District, to identify the limitations of the drought copying and adaptation strategies employed by the small- scale farmers in Musyani ward,

Nakonde District.

4.1 Back ground characteristics of respondents (demographic data)

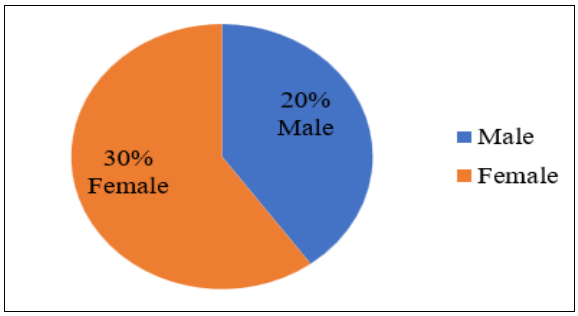


Fig 4.1.1: Graph showing percentage of male vs. female respondents

The age of respondents ranged from early 30s to late 60s, indicating that most farmers are middle-aged or older.

Age of Respondents

The age of respondents ranged from early 30s to late 60s, indicating that most farmers are middle-aged or older.

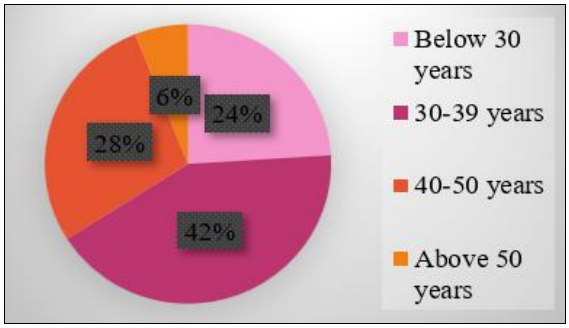


Fig 4.1.2: Respondent age categories (e.g., 30–39, 40–49, 50–59, 60+)

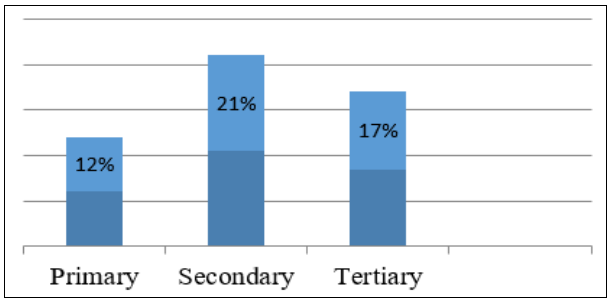


Fig 4.1.3: Frequency table of education level

The chart presents the percentage distribution of individuals across three distinct education levels: Primary, Secondary, and Tertiary. Each category is represented independently, allowing for a clear comparison of educational attainment within the population.

The data indicate that individuals with primary education constitute the largest proportion, accounting for 21.0 percent of the sample. This suggests that a significant segment of the population has attained only basic formal education. Secondary education follows with 17.0 percent, representing a moderate level of educational advancement beyond the primary level.

4.2 Droughts copying and adaptation strategies employed by small scale farmers in Musyani ward, Nakonde District

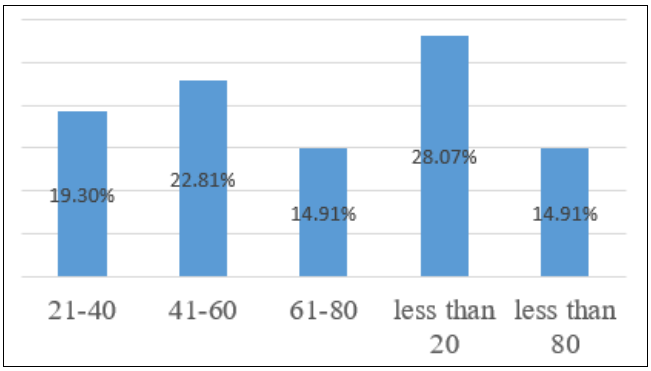


Fig 4.2.1: Shows usual yield percentage lose during drought years

The chart above shows that 28.07% of respondents lose less than 20% of their usual maize yield during drought years, indicating that for some farmers, the effects of climate is relatively mild, and they still manage to maintain a portion of their production despite the challenges. 22.81% of farmers report losing 41-60% of their yield, suggesting that drought significantly affects their production, leading to notable reductions in crop yields. These farmers may experience more severe drought impacts, requiring greater adaptation measures. 19.30% of respondents lose 21-40% of their yield during drought years, highlighting a moderate loss that can still disrupt farmers' livelihoods, although they manage to salvage a portion of their crops. 14.91% of farmers lose 61-80% of their yield, suggesting that for some, drought is a devastating event that results in substantial crop loss, potentially threatening their food security and income.

Lastly, 14.91% of respondent's report losing less than 80% of their yield, indicating that a small portion of farmer's experience near-total loss of their maize crops during drought years, leading to severe economic and food security challenges.

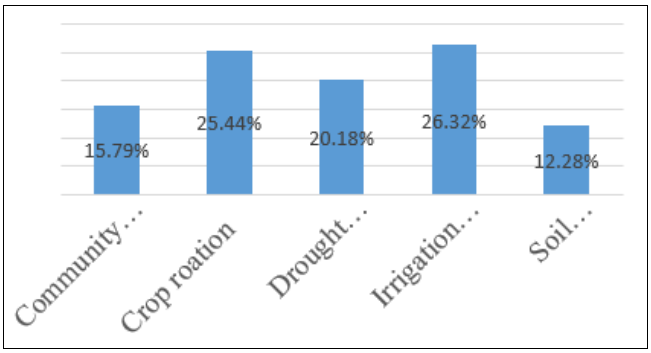


Fig 4.2.2: Shows Adaptation strategies employed to mitigate effects of droughts

The results reveal that the most commonly employed adaptation strategy among farmers is the use of irrigation systems, reported by 26.32% of respondents. Crop rotation is also widely practiced, with 25.44% of farmers using this technique to maintain soil health and reduce the impact of drought on crop yields. Drought-resistant varieties are utilized by 20.18% of respondents, indicating an investment in resilient crops that can withstand dry conditions.

Community support groups, which account for 15.79%, highlight the role of social collaboration in coping with drought-related challenges. Meanwhile, soil conservation techniques are employed by 12.28% of farmers as a method to improve soil moisture retention and prevent erosion.

4.3 presentation of results on effectiveness of drought copying and adaptation strategies employed by the small-scale farmers to enhance household food security in musyani ward, Nakonde District

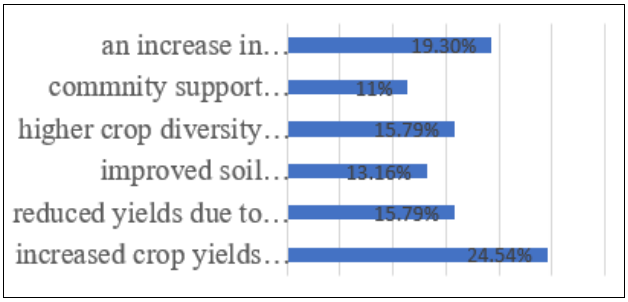


Fig 4.3.1: Effectiveness of the copying and adaptation strategies employed by the small-scale farmers amidst drought on crop yields in Musyani Ward, Nakonde District

The results on the pie chart above indicate the effectiveness of adaptation strategies employed by the small- scale farmers amidst drought on crop yield in Musyani ward, Nakonde District. 24.54% of respondents stated that there was an increase in crop yield and household food security after the implementation of the adaptation strategies. However, 19.54% cited that there was an increase in financial support system as 13.16% of the respondents observed an improvement in soil moisture. However, 15.79% of respondent highlighted are reduced yield due to erratic rainfall and droughts. Interestingly, community financial assistance was only reported by11% of respondents, indicating a significant gap in community support program systems. The reliance on effectiveness of the adaptation strategies by (24.54%) and an increase in financial support system (15.79%) suggests that there is an improvement in the effectiveness of the copying strategies employed by the small -scale farmers in Nakonde District particularly in Musyani ward.

4.4 Presentation of the results on the identification the limitations of the drought copying and adaptation strategies employed by the small -scale farmers in Musyani ward, Nakonde District

Fig 4.4.1: Which of the following is an example of drought limitation adaptation strategies on small scale farmers in Nakonde District

	Freq	Percent
high investment in luxury goods	5	10
Lack of increase in fossil fuel use	25	50
Lack of expanding urban infrastructure	2	4
Lack of practicing crop diversification	18	36
Total	50	100

The study requested respondents to indicate an example of drought limitation adaptation strategies on small scale farmers.

The results of the study reviewed that 10 % of the majority respondents stated that high investment in luxury good, 50 % of the majority respondents stated that it's because of lack of an increase use of fossil and moreover 18 % of the majority respondents said that it's because of lack of practicing crop diversification as the list of the respondents contended that lack of expanding urban infrastructure has contributed to the limitation of the copying strategies implemented by the small scale farmers in Nakonde District.

Table 4.4.2: Frequency of Adoption of Droughts Adaptation Strategies (n = 50)

Adaptation Strategy	Number of Households (n)	Percentage (%)
No Adaptation	20	40%
Soil Management Practices	15	30%
Drought-Tolerant Crop Varieties	15	30%
Total	**50**	**100%**

The frequency table shows that among the 50 surveyed small-scale farmers, 40% did not adopt any climate change adaptation strategies, while 30% practiced soil management and 30% adopted drought-tolerant crop varieties. This indicates that slightly more than half of the households (60%) are taking proactive measures to cope with climate-related challenges. The relatively even distribution between soil management and drought-tolerant varieties suggests that farmers are diversifying their adaptation approaches, which could contribute to improving household food security. However, the fact that a substantial portion of households (40%) have not adopted any strategies highlights a potential gap where interventions or support programs could target non-adopting farmers to enhance resilience.

Table 4.4.3: One-Way ANOVA Showing the Effect of droughts Adaptation Strategies on Household Food Security (n = 50)

Adaptation Strategy	N (Households)	Mean HFIAS Score	Standard Deviation (SD)		
No Adaptation	20	15.30	3.10		
Soil Management Practices	15	12.60	2.80		
Drought-Tolerant Crop Varieties	15	10.80	2.50		
Source of Variation	**Sum of Squares (SS)**	**Degrees of Freedom (df)**	**Mean Square (MS)**	**F-Value**	**Significance (p-value)**
Between Groups	144.87	2	72.43	8.42	0.001
Within Groups	404.53	47	8.61		
Total	**549.40**	**49**			

The analysis of household food security among small-scale farmers revealed significant differences across the three climate change adaptation strategies. Households that did not adopt any adaptation strategies had the highest mean HFIAS score (15.3), indicating greater food insecurity, while those practicing soil management had a lower mean score (12.6), and households adopting drought-tolerant crop varieties had the lowest mean score (10.8), reflecting better

food security. One-way ANOVA confirmed that these differences were statistically significant ($F(2,47) = 8.42$, $p = 0.001$). Post-hoc comparisons using Tukey's HSD test further showed that households without any adaptation practices were significantly more food insecure than those using soil management ($p = 0.022$) or drought-tolerant varieties ($p = 0.001$), whereas the difference between soil management and drought-tolerant varieties was not statistically significant ($p = 0.158$**).** These findings suggest that adopting climate change adaptation strategies particularly drought-tolerant crops has a meaningful positive effect on household food security, highlighting the importance of promoting these practices among small-scale farmers.

The above chart indicates that 21% of respondent's experience drought every 2-3 years, suggesting that drought is a recurring but not annual event for a significant portion of farmers in Nakonde District. This frequency of drought could create periodic challenges for farmers, who must adapt to fluctuating rainfall patterns. 17% of farmer's report experiencing drought less frequently, meaning that for some, drought is not a regular occurrence, but it still impacts their farming activities when it does happen. This could indicate that these farmers may not be as prepared for droughts compared to those who face them more regularly. 12% of respondents say they experience drought every year, highlighting that for a substantial portion of farmers, drought is a persistent problem. This group likely faces more severe and consistent challenges, requiring ongoing adaptation strategies to mitigate the impacts on their maize farming.

Table 4.4.4: Showing Correlation Between Adopter Status and Food Security Score

Variable	Adopter	Food_Security_Score
Adopter	1.0000	0.9019
Food Security Score	0.9019	1.0000

There is a strong positive correlation between adopter status and food security score, with a coefficient of 0.9019. This means that individuals who are adopters tend to have much higher food security scores than non-adopters. The strength of this relationship reinforces the earlier chi-square finding, suggesting that adoption is not only statistically associated with better food security outcomes but also closely aligned in magnitude.

The results presented in the graph above indicates that 21% of respondents have experienced significant effects of drought on their maize production, highlighting a considerable impact on yields and farming activities over the past five years. A close 15% of respondent's report that the effects have been very significant, suggesting that for a substantial portion of farmers, drought has severely impacted their maize crops, likely leading to considerable losses in productivity. 12% of farmers say the drought has affected their maize production moderately, pointing to a moderate, but noticeable, decline in productivity due to dry conditions. Lastly, 2% of respondents report a slightly negative impact, implying that while drought has had some effect, it has not been as severe or disruptive as for other farmers.

4.5 Discussion of Research Findings

The findings of this study reveal that small-scale farmers in Nakonde District are significantly affected by climate variability, with both environmental and farm-level factors shaping crop productivity. The regression analysis demonstrated that rainfall, farm size, and fertilizer use positively influence crop yields, whereas temperature increases, rainfall variability, drought frequency, and flooding exert negative effects. The model explained nearly all variation in crop yield ($R^2 = 0.9784$), highlighting the extreme sensitivity of rain-fed farming systems to local climatic conditions. This aligns with the work of Lobell *et al*. (2021), who emphasized the central role of adequate rainfall and proper input management in smallholder productivity across sub-Saharan Africa. Similarly, Jagtap *et al*. (2022) reported that heat stress and erratic rainfall negatively impact maize yields, underscoring the vulnerability of smallholders. The particularly high explanatory power of the model in Nakonde suggests that environmental factors may outweigh socioeconomic variables, likely because farmers rely heavily on rainfall with limited access to irrigation infrastructure.

In response to these drought challenges, farmers have adopted a range of adaptation strategies, with crop diversification (32%) and early or adjusted planting (24%) being the most prevalent. This finding is consistent with Deressa *et al*. (2019), who found Ethiopian smallholders favor practical and low-cost interventions, and Thornton *et al*. (2021), who noted that farmers prioritize strategies directly linked to minimizing crop failure. However, the lower adoption rates of drought-resistant varieties (16%) and livelihood diversification (10%) suggest barriers such as limited seed availability, high costs, or insufficient knowledge. This contrasts with findings in South Africa (Nhemachena & Hassan, 2017), where improved seeds were more widely used, indicating that local structural and resource constraints shape strategy adoption in Nakonde.

Education emerged as a critical determinant of both adaptation choices and access to credit. Tertiary-educated farmers were more likely to adopt early planting and secure credit, whereas those with primary education exhibited scattered adaptation patterns and limited access to financial resources. This supports the work of Simatele and Simatele (2015), who demonstrated that higher education enhances farmers' capacity to interpret climate information and adopt effective strategies, as well as Feder *et al*. (1985), who linked education to improved access to agricultural credit. The pronounced effect of education in Nakonde highlights the need for targeted training and extension services for less-educated farmers, particularly given the reliance on individual knowledge in rural contexts where social networks may not sufficiently compensate for low literacy levels.

Importantly, the study found a strong positive relationship between the adoption of climate-smart practices and household food security. Farmers using drought-tolerant varieties or soil management practices had significantly lower HFIAS scores (10.8 and 12.6, respectively) compared to non-adopters (15.3), confirmed by ANOVA ($F(2,47) = 8.42$, $p = 0.001$) and Tukey HSD post-hoc tests. Chi-square and correlation analyses further indicated a robust association between adoption status and food security ($\chi^2 = 50.000$, $p < 0.001$; $r = 0.902$). These results are consistent with Bryan *et al*. (2013) and Tesfaye *et al*. (2017), who documented the positive effects of climate-smart agriculture and soil and water conservation on household food security

in East Africa. The exceptionally strong correlation observed in Nakonde suggests that adopting these strategies is not only beneficial but crucial for resilience, while the relatively low uptake of high-impact measures such as drought-tolerant varieties points to a significant opportunity for intervention.

Overall, the findings underscore a clear pattern: farmers' capacity to cope with climate variability and achieve better food security outcomes is shaped by a combination of environmental conditions, practical adaptation strategies, and human capital factors such as education. While environmental factors like rainfall and drought strongly influence yields, proactive adoption of climate-resilient practices mitigates these risks and improves household food security.

5. Conclusion and Recommendations

5.1 Overview

This chapter presents discussion of the findings, draws conclusions based on the objectives of the study. The order of the research objectives was used to arrange the study's conclusions. This chapter also included recommendations resulting from the investigation conducted by the researcher.

5.2 Recommendations

Based on the findings of this study, the following recommendations are proposed to enhance the resilience of small-scale maize farmers in Nakonde District: This is addressed to the authorities such as the government, NGO, and any others willing to improve the agricultural sector.

Expand Access to Drought-Tolerant Seeds: Target distribution of improved drought-tolerant crop varieties to smallholder farmers, prioritizing the 40% of households currently not implementing any adaptation strategies. Extension officers should provide hands-on training on proper planting and crop management to ensure these varieties achieve maximum yield benefits.

Enhance Financial Inclusion for Smallholders: Collaborate with local microfinance institutions and government agencies to create accessible loan schemes enabling farmers to purchase improved seeds, fertilizers, and irrigation equipment. Special focus should be placed on lower-educated and resource-constrained households to ensure equity in accessing these inputs.

Target Non-Adopters with Demonstration Programs: Conduct outreach campaigns and field demonstrations for farmers who currently do not implement adaptation strategies. Demonstrating the tangible benefits of practices like drought-tolerant crops or soil management can increase adoption rates and improve household resilience.

Monitor and Support Adaptation Impact: Establish a local monitoring system to track adoption rates, crop yields, and food security outcomes. This will help identify which strategies are most effective, which farmers are being left behind, and where additional interventions are needed.

Integrate Policy and Community Support: Advocate for policies that ensure consistent supply of improved seeds, affordable fertilizers, and climate information. Community-level support groups can also facilitate knowledge exchange, cooperative resource management, and collective problem-solving, reducing barriers for smallholder farmers.

5.3 Conclusion

This study investigated the effects of climate change on small-scale farmers in Nakonde District, Zambia, the adaptation strategies they employ, and the impact of these strategies on household food security. The findings reveal that smallholder farmers are highly vulnerable to drought variability. Crop yields are significantly influenced by rainfall, farm size, and fertilizer application, while temperature increases, irregular rainfall patterns, drought frequency, and flooding exert strong negative effects. This underscores that environmental factors play a dominant role in determining productivity in rain-fed farming systems, and even minor variations in climate conditions can have profound consequences for household food security.

Farmers employ a range of adaptation strategies, yet adoption is uneven. Crop diversification (32%) and early planting (24%) are the most common, reflecting farmers' preference for practical and low-cost measures to reduce immediate risks of crop failure. However, adoption of drought-tolerant crop varieties (16%) and soil and water conservation practices (18%) remains limited. Importantly, 40% of households do not implement any adaptation strategies, which leaves a substantial portion of the population highly exposed to climatic shocks. This uneven adoption highlights structural barriers such as limited access to improved seeds, inadequate knowledge, labor constraints, and financial limitations, which restrict farmers' ability to enhance resilience.

Education plays a central role in determining both the adoption of effective strategies and access to credit. Farmers with tertiary education are more likely to adopt proactive practices like early planting and to access credit for inputs, while those with primary and secondary education exhibit scattered adaptation patterns and limited access to financial resources. This demonstrates that human capital is a critical enabling factor for resilience. The study further confirms that adoption of climate-smart strategies strongly improves household food security, as shown by significantly lower HFIAS scores among adopters and a strong positive correlation ($r = 0.902$). However, despite the clear benefits, the low adoption rate of high-impact strategies, combined with socioeconomic barriers, indicates persistent gaps in equity and resilience across Nakonde's smallholder population.

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