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Examining Effectiveness of Adaptation Strategies by Small Scale Maize Farmers against Climate Change: Case Study of Small-Scale Farmers in Ngwezi-2 Area of Mazabuka

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Abstract

This study examines adaptation strategies by small-scale maize farmers in Ngwezi-2, Mazabuka, Zambia, from 2019 to 2024 amid increasing droughts and floods linked to climate change. Droughts became more frequent, peaking with three occurrences in 2024. Maize yields declined significantly: Yield losses reached 800 kg/hectare during droughts and 600 kg/hectare in floods. For instance, in 2023, average maize yield fell 40% from 2000 kg/ha in 2022 to 1200 kg/ha due to severe droughts (Figure 4.8). Farmers adopted various adaptation strategies to mitigate yield losses. Crop diversification increased from 10 farmers in 2019 to 12 in 2024, while drought-resistant seeds, irrigation, conservation agriculture, and agroforestry were also employed (Table 4.5). These measures improved yields by about 20-30% during drought years. However, barriers remain: High costs, limited access to resources, and difficulties scaling complex interventions like irrigation. Economic and social adaptations, such as income diversification (e.g., poultry rearing) and microfinance, helped lessen the financial impacts of reduced maize yields. These findings underscore the need for more targeted support to strengthen farmers' resilience and cope with intensifying climate variability. With strategic interventions, small-scale farmers can better sustain production and livelihoods as climate-related challenges intensify. Research and policy support can enhance availability, enabling measure adoption.

Keywords: Climate Change, Adaptation Strategies, Small-Scale Farmers, Maize Production, Drought, Floods, Crop Diversification, Drought-Resistant Seeds, Irrigation, Economic Resilience, Zambia

1. Introduction

The chapter outlines the research problem, objectives, and significance of the study, emphasizing the urgency of enhancing climate resilience in small-scale farming systems. It also provides context on the vulnerability of the Mazabuka region to changing climatic conditions and how this affects maize farming practices.

1.1 Background

Given the general agreement that the earth's climate will change by the end of this century (IPCC, 2018) [14], worries regarding the short, medium and long-term effects of climate change on agriculture are present on a national, regional, and global scale. The relationship between climate change and agriculture has been the subject of an increase in empirical research as a result of these worries. In this regard, the majority of the groundbreaking efforts are centered on the United States. How geographic factors impact a nation's crop production is one topic that hasn't been thoroughly examined in the SSA climate change-agriculture sector.

The impact of geographical impacts on a nation's agricultural production is one topic that has not been thoroughly examined in the SSA climate change-agriculture literature. For instance, geographical features, agroclimatic conditions, and incidental commonality can all lead to spatial correlations (Di Falco and Chavas, 2019; Miao *et al*., 2015). Furthermore, the use of gridded weather datasets produced using extrapolation means results in notable spatial correlations (Auffhammer *et al*., 2013, Baylis *et al*., 2017). Prior research on climate change and Africa has not examined the effects of these spatial impacts. While Schlenker and Lobell (2020) and Ward, Florax, and Flores-Lagunes (2023) attempt to account for geographical correlation among the error factors, none of them employ formal spatial panel technique.

Spatial implications on agricultural yields are one aspect of SSA climate change agriculture that has not been thoroughly investigated. The continent of Africa's food security is increasingly at risk from climate change. A significant contributor as well as a victim, agriculture emits potent greenhouse gasses. For crops to flourish, the proper balance of heat, sunlight, water, and soil is required. However, this equilibrium is being disrupted by climate change, particularly in terms of the duration of the growing season for farmers.

According to Sacko (2024), if proper response measures are not implemented, it is predicted that up to 118 million extremely poor people in Africa will be exposed to drought, floods, and extreme heat by 2030. Climate change in Africa is also predicted to add to the burden of efforts to reduce poverty and reduce GDP by up to 3% by 2050. In a continent that experiences over 100 disease outbreaks annually along with numerous other crises and disruptions, climate adaptation and resilience initiatives face significant obstacles.

Many researchers have shown that the impacts of climate change across countries around the world are different and cannot be quantified in a similar way (Goglio *et al*., 2020; Miles and Churkina, 2020; Lezaun, 2021). These effects tend to differ in relation to existing adaptation and reduction strategies, as well as the resources these countries undertake (IPCC, 2020; Brugger *et al*., 2021; Ceci *et al*., 2021).

1.2 Statement of the problem

Climatic variability impacts different crops in different ways, but most impacts have been shown to be negative (Asseng *et al*. 2011; Krishnan *et al*. 2011; Tiwari and Yadav 2019). Climatic variability and change have contributed to the reduction in yields of major cereal crops in regions of smallholder dominance like South Asia (Aryal *et al*. 2020; Khatri-Chhetri and Aggarwal 2017; Lal 2011). Although adaptive agronomic decisions (e.g. changing crop management) can contribute towards lowering the yield gap (Bryan *et al*. 2014), such practices must be adapted to diverse socioeconomic context of smallholder systems (Khanal and Wilson 2019). There are considerable ambiguities on the frequency, severity, and location of climatic impacts, even while areas with a preponderance of smallholders exhibit an increasing trend of rising temperatures and variability in precipitation patterns (Krishnan *et al*. 2019; Lal 2011). Dynamic and adaptable solutions to deal with climatic and non-climatic stressors are necessary to sustain smallholder agriculture in developing nations (Mishra *et al*. 2019; Morton 2007 [19]). To maintain and boost agricultural output in smallholder systems with microclimatic and socio-ecological variation, contextually appropriate adaptation strategies must be implemented (Aryal *et al*. 2020).

Since the mining industry, which served as Zambia's economic backbone from 1964 until the late 1980s, agriculture has grown in importance within the country's economy (Muchinda, 2001). More than 60% of the population depends on the agriculture industry for their living, and it contributes between 18% and 20% of the nation's GDP. About two-thirds of the workforce is employed there (Muchinda, 2001). In the past 20 years, the frequency and severity of droughts have increased, impacting Zambian agriculture despite its primary importance to the country's citizens.

1.3 General objective

The purpose of the research is to examine effectiveness of adaptation strategies by small scale maize farmers against climate change. The Specific objectives of effectiveness of adaptation strategies by small scale farmers against climate includes the following: To examine how small-scale farmers are adapting to climate change on maize production, to assess how climate change has affected maize production and to establish how small-scale farmers are responding to the shocks faced in maize production.

1.4 Theoretical framework

In order to assess yield changes under different climate scenarios, Mendelsohn *et al*. (1994) developed the AEZ technique, which integrates environmental factors like temperature and rainfall into production models. According to Li *et al*. (2009) and other worldwide simulations, major crops would have yield decreases of more than 50% by 2050 as a result of heightened drought risks by 2100. In the absence of technical advancements, Hijmans (2003) predicted a global potato output decline of 18–32% by 2069, whereas Parry *et al*. (2004) emphasized significant yield decreases under the A1F1 climatic scenario.

Research in Africa showed significant effects on agricultural output. For example, Barrios *et al*. (2004) discovered that yields in Sub-Saharan Africa are greatly impacted by climate fluctuation. In a similar vein, Deressa and Hassan (2009) demonstrated that warmer scenarios resulted in lower net farm revenues. Zhai and Zhuang (2009) projected minor economic implications in Southeast Asia, but severe effects on less economically diversified nations.

Lobell and Field (2007) estimated that $5 billion in losses occurred annually worldwide as a result of rising temperatures, which they related to yield reductions for crops like maize and wheat. By the middle of the century, Schlenker and Lobell (2010) [24] predicted that maize yields in Sub-Saharan Africa would have decreased by 22%, highlighting the sensitivity of high-yield regions to heat. These results highlight the significance of adaptation measures, since adverse effects worsen in the event of unchecked climate change.

1.5 literature review

In Zambia, where more than half of the population lives below the national poverty line, the effects of climate change on poverty are severe (CSO, 2015). Al Mamun *et al.* (2018) [3] discovered in a cross-country study that poverty in Eastern and Southern Africa was exacerbated by the El Niño meteorological phenomenon7. El Niño in 2015–2016 was linked to severe droughts and floods in many regions of Zambia. According to Al Mamun *et al*. (2018) [3], Zambia's poverty gap widens by 1.9 percentage points and the country's poverty rate rises by 1 percentage point with every 10% decrease in maize yields.

As anticipated, rural areas have seen increases in the poverty rate and gap that are roughly 16 and 10 times greater than those in urban areas, respectively. A 10 percent decrease in maize prices also raises the poverty gap by 2.4 percentage points in rural regions and the poverty rate by 1.16 percentage points, according to the report. In Zambia, the drought shocks caused by El Niño in 2015–2016 resulted in decreases of roughly 20 percent in maize yields and 37 percent in per capita incomes, according to Alfani *et al*. (2019) [4]. According to Braimoh *et al*. (2018) [6], climate shocks like droughts and floods in Zambia lower cotton productivity by an estimated 68% and maize and groundnut yield by 33%. Although it is widely accepted that climate and weather shocks have the capacity to exacerbate poverty and vulnerability while undermining resilience, it is yet unknown how these effects differ among Zambian household types and geographical areas, as well as how much the poor are exposed to weather shocks.

According to the Sixth National Development Plan (SNDP), poverty in Zambia reached 68% at the national level and 78% at the rural level in 2004. 70% of Zambians are classified as poor, while 60% of the country's population lives in rural areas, according to the SNDP. The vast majority of Zambians living in rural areas rely on agriculture or livelihoods related to it, yet these sectors have remained impoverished because of a lack of infrastructure and support services like marketing and extension. Agriculture has received only 5% of the yearly budget from the government (FNDP 2006). Small-scale farmers in rural areas are therefore classified as impoverished, work primarily in the unorganized sector, and are forced to relocate to cities in pursuit of better opportunities. The unequal distribution of national resources is demonstrated by the high rate of poverty in rural areas relative to urban ones.

According to a 2015 UNDP research on farmer problems, agriculture can raise living standards. Both primary and secondary data were collected as part of the technique. The assessment's findings showed that, despite the existence of legislation that support the mainstreaming of gender equality in the agriculture industry, there is a disconnect between the two. Due to inadequate financial and human resources, MGCD, the national gender machinery, is unable to fulfill its mandate.

A transparent payment fund that ensures prompt payment of all redeemed vouchers must be established by the government. Without this assurance, the E-voucher program would be undermined because it is doubtful that enough private actors would enter the market. v. The government will implement the payment system and begin identifying beneficiaries. Investing in the identification of suitable fertilizers for each agro-ecological region should be a top priority. Additionally, make sure extension officers receive the necessary training and timely resources to properly communicate this information.2. To help the weak, the government ought to think about investing more in social cash transfers. Cash transfers have been shown to be successful in supporting low-income households and promoting local economic growth. 3. High-level political will is required to implement the aforementioned proposals.

Personal critique of the literature review

The literature study provides a thorough summary of the significant impacts of climate change on Zambia's poverty and maize output, with a focus on the implications of the El Niño weather phenomena. The paper skillfully illustrates the crucial connection between lower maize yields and higher rates of poverty, proving a direct correlation between socioeconomic circumstances and agricultural production.

Though the wealth of information regarding the relationship between poverty and climate change is clearly stated, a more thorough examination of the particular adaptation tactics used by small-scale farmers would enhance the literature. Climate Smart Agriculture (CSA) methods are mentioned in the review, although it tends to generalize the results without providing a thorough study of the efficacy of particular CSA programs in various contexts.

Furthermore, although resilience and gender equality are mentioned, a more thorough examination of these topics is necessary to completely comprehend their functions in adaption tactics. All things considered, the review does a good job of setting the stage for analyzing the complex issues small-scale farmers confront, but it should include more detailed information about adaptation strategies and the subtle effects of climate change on different populations.

Establishment of research gaps

We discovered that smallholder farmers in Zambia are more susceptible to droughts, which are a more common climate shock that affects rural communities. Although the degree of exposure varies over time and space, Zambia's Western and Southern Provinces are generally the most vulnerable to climate shocks. Almost one-quarter of smallholders nationwide are resilient, while approximately three-quarters are vulnerable.The Eastern, Muchinga, Northern, and North-western Provinces are the most vulnerable, however there are significant regional variations. There is a strong association between (i) climatic shocks and increased susceptibility and (ii) climate shocks and decreased resilience, according to our multivariate analysis. Additionally, we discovered some evidence that suggests smallholder farmers in Zambia are more vulnerable and less resilient when they have assets and education, whereas female-headed families are less resilient and more vulnerable. A household's likelihood of becoming resilient in the near future is higher when CSA is used.Therefore, we draw the conclusion that the majority of Zambia's smallholder farmers are vulnerable to climate shocks and that resilience and vulnerability are linked to climate shocks. Although attempts to provide insurance programs have been made in Zambia, it is unclear if these initiatives have been successful or how to make them work for smallholders.Facilitating asset accumulation and resilience-boosting education are two other crucial complimentary components.

2. Research Methodology

This chapter details the research methodology used to evaluate the effectiveness of adaptation strategies among small-scale maize farmers in Ngwezi-2, Mazabuka. Employing a mixed-methods approach, the study combines quantitative surveys with qualitative interviews and focus group discussions. Surveys capture farmers' adaptation strategies and their perceived effectiveness, while interviews with agricultural extension officers and local leaders provide qualitative insights. A stratified random sampling technique ensures diverse representation, while data analysis employs descriptive and inferential statistics for quantitative data and thematic analysis for qualitative data. Ethical considerations, such as informed consent and confidentiality, are prioritized, and limitations, including generalizability and resource constraints, are addressed.

The study utilizes a case study design, focusing on the “what and why” of adaptation strategies to climate change. Yin’s (1994) description of research design as a “blueprint” for addressing research questions guides the approach. This design enables an in-depth exploration of farmers’ strategies within their local context. Additionally, a purposive sampling method selects information-rich participants to ensure the data is relevant and insightful, while interviews, focus groups, document analysis, and questionnaires are used for triangulated data collection, enhancing validity and reliability.

Data analysis incorporates both qualitative and quantitative paradigms. Qualitative data is analyzed using thematic and inductive methods, while quantitative data is processed using SPSS for statistical analysis. The study employs triangulation through diverse data sources and frameworks, such as resilience theory, to strengthen findings. Ethical protocols, including confidentiality and voluntary participation, are strictly followed, ensuring the study adheres to ethical research standards.

While the study provides valuable insights, it has limitations, such as the reliance on self-reported data, a geographically specific focus, and a cross-sectional design that restricts long-term trend analysis. Nonetheless, the methodology offers a robust framework for understanding the adaptation strategies of small-scale farmers in the face of climate change.

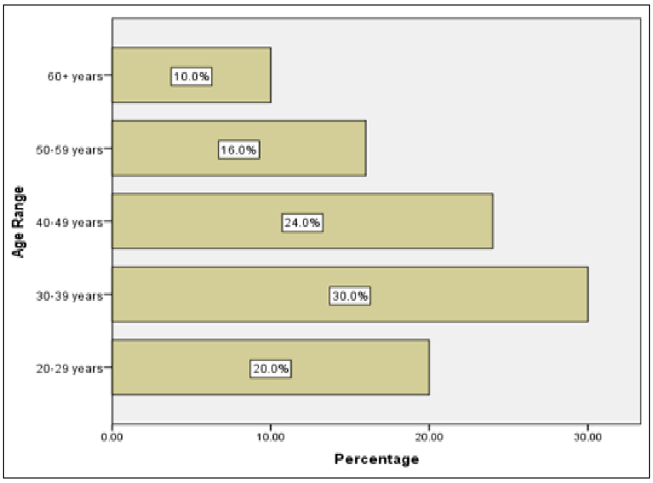
3. Research Findings and Discussions

Presentation of Results on Background Characteristics of the Respondents

a) Age Distribution of Respondents

The majority of farmers fall within the 30-39 years age bracket (30%), followed by 40-49 years (24%). This suggests that most farmers are in their prime working years. Younger farmers, aged 20-29, account for 20%, while older farmers (50 years and above) represent a smaller portion (26%), indicating an age distribution skewed towards middle-aged individuals.

a) Gender Composition of Respondents



A larger proportion of farmers are male (64%), compared to females (36%), suggesting a gender imbalance in the farming population.

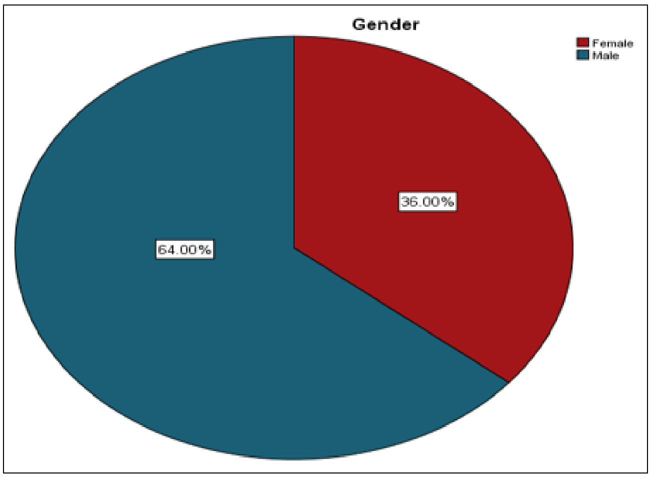
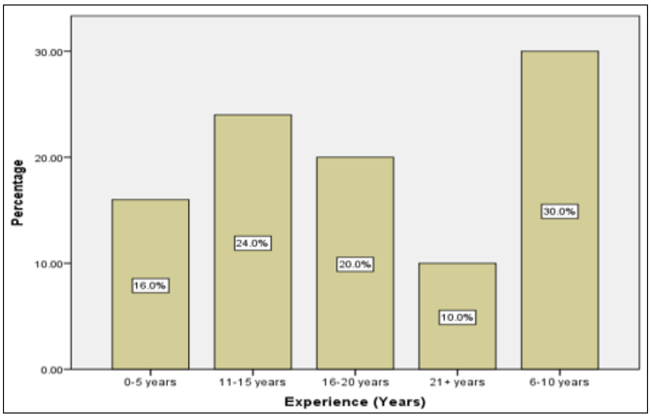


Fig 4.2: Gender Composition of Respondents

b) Education Level of Respondents

Farming experience is fairly distributed, with 30% of respondents having 6-10 years of experience and 24% having 11-15 years. This indicates that the majority of farmers are relatively experienced, which may influence their choice and effectiveness of adaptation strategies in response to climate change. A smaller group of farmers (16%) are relatively new to farming with 0-5 years of experience.

c)Years of Farming Experience



The background characteristics of the respondents provided valuable insights into the demographic composition of small-scale farmers in Farmers in Ngwezi-2 Area of Mazabuka.

d) Adaptation Strategies Used by Farmers

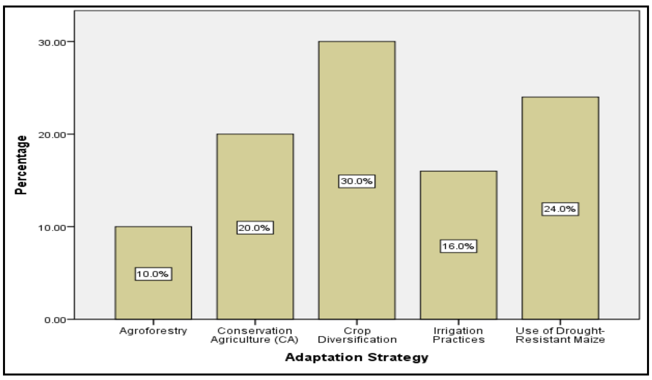
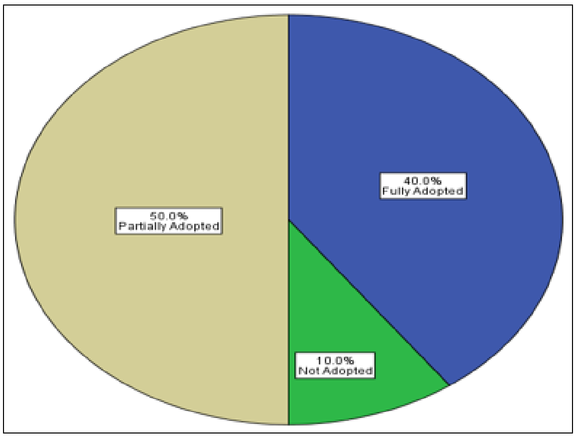


Figure 4.6 shows the adaptation strategies used by farmers reveals a range of responses to climate change in maize production. The most common strategy is crop diversification, with 30% of farmers adopting it, likely due to its ability to spread risks across different crops. Conservation agriculture (CA) is employed by 20% of farmers, helping to enhance soil health and water retention. The use of drought-resistant maize is adopted by 24% of the farmers, reflecting the importance of resilience to drought conditions. Irrigation practices are used by 16% of farmers, indicating limited access to water resources or irrigation infrastructure. Finally, agroforestry, adopted by 10% of farmers,

Level of Adoption of Adaptation Strategies

The findings on the Level of Adoption of climate change adaptation strategies among small-scale maize farmers in Ngwezi-2 Area of Mazabuka provide insight into the extent to which these practices are being implemented. Level of Adoption indicate varying degrees of adoption of climate change adaptation strategies among the small-scale maize farmers in Ngwezi-2 Area of Mazabuka. Of the respondents, **40%** have fully adopted the strategies, reflecting a significant portion of farmers who have integrated these methods into their farming practices. **50%** have partially adopted the strategies, suggesting that while they are aware of and implementing some aspects of adaptation, there are still gaps in full adoption. Lastly, **10%** have not adopted any of the strategies, highlighting the presence of barriers to implementation for a small segment of the farming community.

e) Education Level and Adopted (Yes)



Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.000a	16	.220
Likelihood Ratio	16.094	16	.446
N of Valid Cases	5		

a. 25 cells (100.0%) have expected count less than 5. The minimum expected count is .20.

f) Education Level * Adopted (No)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.000a	12	.241
Likelihood Ratio	13.322	12	.346
N of Valid Cases	5		

a. 20 cells (100.0%) have expected count less than 5. The minimum expected count is .20.

Interpretation of the Results:

The cross-tabulation test was conducted to assess whether there is a statistically significant association between education level and the adoption of adaptation strategies by small-scale maize farmers.

- **For Adopted (Yes):** The Pearson Chi-Square value is 20.000, with a degree of freedom (df) of 16. The p-value is 0.220.
- **For Adopted (No):** The Pearson Chi-Square value is 15.000, with a degree of freedom (df) of 12. The p-value is 0.241.

P-Value Interpretation:

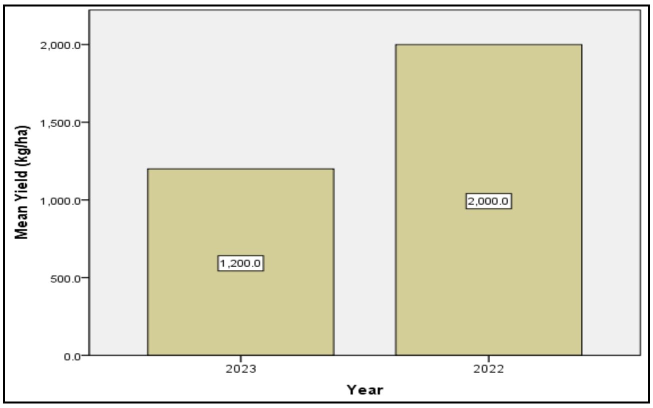
- The p-value for Adopted (Yes) is 0.220 and for Adopted (No) is 0.241. Since both p-values are greater than 0.05, this means that there is no statistically significant association between education level and the likelihood of adopting climate change adaptation strategies in this sample.

No significant association was found between the level of education and the adoption of climate change adaptation strategies among small-scale maize farmers in the Ngwezi-2 area of Mazabuka. These results suggest that the education level of farmers does not significantly influence whether they adopt climate change adaptation strategies.

h) Change in Maize Yield Due to Drought

Year	Yield (kg/ha)	Frequency
2022	2000	50
2023	1200	50

The yield recorded in 2022, prior to the climate drought, was **2000 kg** per hectare. This reflects a period when maize production was relatively stable and productive, allowing farmers to achieve optimal yields.In contrast, the yield reported in 2023, following the climate drought, dropped to **1200 kg** per hectare. This represents a **40% decrease** in yield, signifying a dramatic impact of climate change and associated drought conditions on maize production.



The 40% reduction in yield emphasizes the urgency for research and policy interventions aimed at enhancing resilience against climate-related challenges in agriculture.

g) How Climate Events Affect Maize Production in the Ngwezi-2 Area

Year	Climate Event	Frequency	Impact on Yield (kg/hectare)
2019	Drought	15	-800
2020	Flood	10	-600
2021	Drought	20	-1000
2022	Drought	25	-1200
2023	Flood	5	-500
2024	Drought	30	-1500
2024	Flood	25	-700

The data shows a trend of increasing frequency and impact of droughts over the years, with the highest number of farmers affected (30) and the most substantial yield loss (-1500 kg/hectare) recorded in 2024.

Impact of Drought on Maize Production

i) Change in Maize Yield and Occurrence of Droughts/Floods

Variable

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	- Decrease	2	9.1	9.1	9.1
	- Earlier	1	4.5	4.5	13.6
	- High	1	4.5	4.5	18.2
	- Increase	2	9.1	9.1	27.3
	- Later	1	4.5	4.5	31.8
	- Low	1	4.5	4.5	36.4
	- Moderate	1	4.5	4.5	40.9
	- No	2	9.1	9.1	50.0
	- No Change	1	4.5	4.5	54.5
	- Unchanged	2	9.1	9.1	63.6
	- Yes	2	9.1	9.1	72.7
	Change in Maize Yield	1	4.5	4.5	77.3
	Changes in Planting Seasons	1	4.5	4.5	81.8
	Occurrence of Droughts/Floods	1	4.5	4.5	86.4
	Pest and Disease Incidence	1	4.5	4.5	90.9
	Soil Moisture Levels	1	4.5	4.5	95.5
	Use of Irrigation	1	4.5	4.5	100.0
	Total	22	100.0	100.0	

Cross Tabulation Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.000[a]	9	.013
Likelihood Ratio	11.090	9	.020
N of Valid Cases	4		

a. 16 cells (100.0%) have expected count less than 5. The minimum expected count is .25.

The p-value < 0.05: There is a statistically significant association between Change in Maize Yield and Occurrence of Droughts/Floods.

j) Impact on Maize Production

Year	Climate Change	Frequency of Events	Impact on Yield	Adaptation Strategy Used	Frequency of Strategy Use
2019	Drought	1	-20	Crop Diversification	10
2020	Flood	1	-15	Conservation Agriculture	5
2021	Drought	2	-30	Use of Drought-Resistant Seeds	15
2022	Drought	2	-25	Irrigation	8
2023	Flood	1	-10	Agroforestry	7
2024	Drought	3	-35	Crop Diversification	12

Climate Change Events: Droughts are more frequent than floods, with multiple drought events occurring in several years (e.g., 2021, 2022, and 2024). This highlights the ongoing challenges farmers face with water scarcity.Impact on Yield: Yields have been consistently affected by these events, with droughts causing higher yield losses compared to floods. For example, in 2024, the yield impact due to droughts was the most severe, with a reduction of 35 kg/hectare.

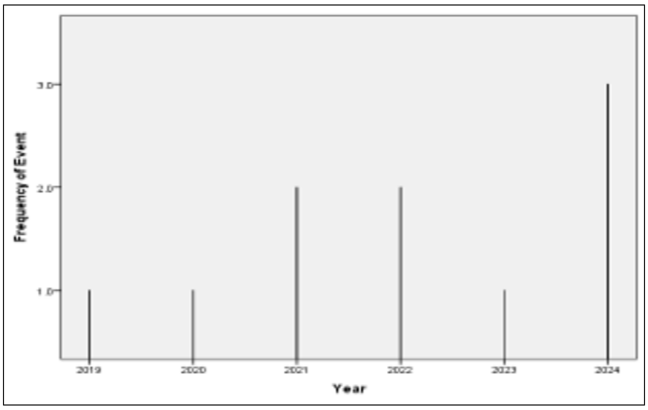


Figure 4.9 shows an increasing frequency of climate change events (droughts and floods) impacting the area from 2019 to 2024. Drought occurrences have risen more sharply, with one drought in 2019 and reaching three in 2024. Floods, meanwhile, have remained infrequent, with only one instance in 2020 and 2023 each. This trend indicates a notable rise in droughts over the years, suggesting growing water scarcity challenges that could significantly affect agriculture and local livelihoods.

Economic and Social Adjustments to Climate Shocks

Small-scale farmers in Ngwezi-2, Mazabuka, face challenges from climate-induced shocks, including reduced maize yields due to frequent droughts, flooding, and shifting growing seasons. To cope, they employ various economic and social strategies to sustain their livelihoods.

Income Diversification like vegetable gardening, poultry rearing, and livestock production. For example, growing drought-resistant vegetables provides food and income during maize failures, reducing economic vulnerability. Diversified income sources help farmers manage crop losses and financial pressures.Microfinance loans and savings schemes enable farmers to buy inputs like seeds, fertilizers, and irrigation equipment, enhancing productivity during adverse conditions. Cooperative savings groups help farmers share costs for climate-resilient practices, though high interest rates on loans often limit accessibility.

k) Climate Event and Adaptation Strategy Crosstabulation

Cross Tabulation Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.000[a]	4	1.000
Likelihood Ratio	.000	4	1.000
N of Valid Cases	10		

a. 10 cells (100.0%) have expected count less than 5. The minimum expected count is 1.00.

Based on the cross-tabulation test of Independence results in Table 4.12, there is no statistically significant association between the type of climate event (drought or flood) and the adaptation strategy used by farmers. The Pearson Chi-Square valueis0.000 with a p-value of 1.000 (significance level). This p-value exceeds the common significance threshold (e.g., 0.05), indicating that we do not have sufficient evidence to reject the null hypothesis, which states that there is no association between climate event type and the adaptation strategy.

The results imply that farmers do not appear to select their adaptation strategies based on whether the event is a drought or a flood. Instead, they may be employing these strategies uniformly regardless of the type of climate event.

This uniform approach could reflect a limited set of available adaptation options or a general application of strategies aimed at building overall resilience, rather than specific responses to droughts versus floods.

Effectiveness and Challenges of Current Adaptation Strategies

Adaptation strategies such as crop diversification, conservation agriculture, drought-resistant seed varieties, and irrigation practices are key responses to climate shocks affecting maize production. Crop diversification reduces vulnerability by spreading risk across multiple crops, while drought-resistant varieties and conservation agriculture provide protection against crop failure and require less water, though their effectiveness depends on environmental conditions (Adger, 2000) [1].

In Ngwezi-2, farmers using these strategies report improved yields and resilience compared to those relying on traditional methods. Drought-resistant maize varieties have boosted yields by 20–30% during drought years, aligning with findings from other Sub-Saharan African studies.

3.3 Discussion of Research Findings

The research findings analyze the effectiveness of adaptation strategies used by small-scale maize farmers in Ngwezi-2, Mazabuka, in response to climate change impacts. Key themes include adaptation methods, their success, socioeconomic and environmental influences, and challenges in implementation. The study contextualizes these findings within existing literature, highlighting areas where adaptation efforts have succeeded and where further support is needed to enhance resilience and sustain maize production amid ongoing climate changes.

Farmers employ various adaptation strategies, with crop diversification (30%) being the most common, followed by drought-resistant maize varieties (24%), conservation agriculture (20%), irrigation (16%), and agroforestry (10%). These approaches help mitigate risks from climate variability, such as droughts and floods, but adoption varies due to resource availability, access to information, and costs. While 40% of farmers have fully adopted these strategies, 50% have only partially implemented them, and 10% have not adopted any measures, underscoring barriers like limited financial and informational support.

Droughts were identified as the most frequent and severe climate events, significantly reducing maize yields. For example, from 2019 to 2024, drought occurrences increased, culminating in a 40% yield decrease in 2023. Statistical analysis confirmed a strong association between climate events and yield changes, emphasizing the need for effective strategies like drought-resistant seeds, improved irrigation, and diversified farming practices to cushion the effects of these climatic extremes.

Adaptation strategies show varied effectiveness. Drought-resistant seeds and conservation agriculture improved yields by 20-30% in drought years. However, irrigation and agroforestry remain underutilized due to resource constraints and high costs. Economic and social adjustments, including income diversification, microfinance, and labor reallocation, supplement these practices, while community support networks provide critical safety nets during crises. These findings highlight the need for targeted interventions to enhance resource access and knowledge dissemination, ensuring broader adoption of climate-resilient practices.

4. Conclusion and Recommendation

Conclusion

The study concluded that the findings of this study highlight the resilience of small-scale maize farmers in Ngwezi-2 Area of Mazabuka in the face of climate change. Farmers are adopting various strategies to sustain maize production, but the level of adoption varies. The study clearly indicates that small-scale maize farmers in Ngwezi-2, Mazabuka, are facing significant challenges due to the effects of climate change, with droughts and floods being the most critical climatic events affecting maize production. The 40% reduction in maize yield observed in the aftermath of drought conditions further highlights the urgency for effective adaptation strategies. Despite some positive strides made in the adoption of these strategies, there is a need for continued efforts to enhance farmers' resilience to climate change through targeted interventions, capacity building, and the provision of resources. The statistical findings also suggest that specific strategies need to be implemented to address the increasing occurrence and severity of climate events and their profound impact on food security in the region.

The findings of this study underscore the urgent need for targeted interventions that support small-scale farmers in the Ngwezi-2 area in adapting to climate change. While farmers have adopted a variety of strategies to cope with the changing climate, the effectiveness of these strategies is often limited by factors such as access to resources, knowledge, and financial support. To enhance resilience, it is crucial to provide farmers with the necessary tools, training, and financial assistance to scale up effective adaptation practices.

Recommendation

Strengthen access to climate-resilient inputs such as drought-resistant seeds and promote their adoption through targeted subsidies.

Provide comprehensive training on sustainable practices like conservation agriculture to enhance soil moisture retention and productivity.

Establish community-based irrigation schemes to reduce dependence on unpredictable rainfall patterns.

Develop localized climate monitoring systems to provide timely weather information for informed decision-making by farmers.

Increase investment in research on the specific impacts of drought and flooding on maize yields in the Ngwezi-2 area.

Promote crop diversification as a risk-reduction measure to minimize losses caused by extreme weather events.

Facilitate access to microfinance and cooperative savings programs to enable farmers to invest in adaptive measures.

Encourage collaboration between government, NGOs, and communities to create effective support networks for farmers facing climate shocks.

Implement public awareness campaigns to improve knowledge of climate adaptation strategies and available support systems.

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