

# The Role of Climate Change Adaptation Strategies in Enhancing Food Security Among Smallholder Farmers in Kabwe District, Zambia

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Publication Date: 2026/04/28

**Abstract:** This study investigates the impact of smallholder adaptation strategies on maize food security in Kabwe District, Zambia. Against a backdrop of increasing climate variability, smallholder farmers, who form the backbone of Zambia's maize production, face recurring challenges such as droughts, erratic rainfall patterns, and rising temperatures. In response, many farmers have adopted various adaptive practices aimed at sustaining yields and protecting household food security. This research aims to assess the effectiveness of these strategies and determine the extent to which they have contributed to mitigating food insecurity among maize-dependent households. A mixed-methods approach was employed, combining quantitative data from structured questionnaires with qualitative insights from in-depth interviews with selected smallholder farmers. Findings demonstrate that while adaptation strategies, such as minimum tillage which is at 60%, pruning and use of drought-resistant/early maturity seed have had a positive impact on maize production and food availability which is at 90%, their effectiveness is significantly influenced by socio-economic and institutional factors. Farmers with better access to extension services and agricultural inputs were more likely to achieve food security. Conversely, barriers such as high input costs, inadequate tools, and weak extension networks constrained effective adaptation. The study concludes that although smallholder adaptation is making a meaningful contribution to food security in Kabwe District, there is a critical need for stronger institutional support, input subsidies to ensure long-term resilience and sustainability.

**Keywords:** Climate Change, Food Security, Resilience, Adoption Strategies, Smallholder Farmers.

**How to Cite:** Mukwalikuli Mundia; Mufalali Mwiya Simasiku; Godfrey Banda; Regina Muduli; Passy Haachizo; Cloudy Hamyongwa (2026) The Role of Climate Change Adaptation Strategies in Enhancing Food Security Among Smallholder Farmers in Kabwe District, Zambia. *International Journal of Innovative Science and Research Technology*, 11(3), 4065-4075. <https://doi.org/10.38124/ijisrt/26mar1473>

## I. INTRODUCTION

Climate change poses one of the most pressing challenges to global food security, with smallholder farmers in sub-Saharan Africa among the most vulnerable to its adverse effects. In Zambia, maize is not only the staple crop but also a critical source of livelihood for the majority of rural households (Kanyanga et al., 2012). Kabwe District, situated in Zambia's Central Province, has experienced increasing climate variability over the past two decades, manifesting in unpredictable rainfall patterns, prolonged dry spells, and recurrent droughts. These climatic shifts have resulted in fluctuating maize yields, threatening household food availability and undermining the economic stability of smallholder farmers. Addressing these challenges requires proactive and context-specific climate change adaptation strategies that can sustain and enhance maize production. (Makondo et al., 2024).

Climate change adaptation refers to adjustments in agricultural practices, technologies, and livelihoods to minimize vulnerability and harness potential opportunities arising from climatic shifts. For smallholder maize farmers in Kabwe, adaptation measures include conservation agriculture, crop diversification, adoption of drought-tolerant maize varieties, irrigation development, and improved post-harvest storage techniques (De Brooke et al., 2013). These strategies not only enhance resilience to climatic stressors but also have the potential to improve productivity and reduce post-harvest losses. By embedding adaptation into farming systems, farmers can better cope with seasonal uncertainties, safeguard maize yields, and contribute to long-term food security at both household and community levels (Gammon et al., 2014).

Food security encompasses four key dimensions: availability, access, utilization, and stability. Climate change directly threatens each of these, particularly for maize-

dependent smallholder households (Jain et al., 2007). Adaptation strategies can play a pivotal role in strengthening all four dimensions ensuring maize remains available through improved yields, accessible through stable prices, nutritionally adequate through diverse production systems, and stable across seasons despite climatic variability (Ngoma et al., 2021). However, the effectiveness of these adaptation measures depends on factors such as farmers' access to resources, extension services, market infrastructure, and policy support. Understanding these linkages is essential for designing interventions that translate adaptation efforts into tangible food security outcomes. (Sianungu., 2021).

Although numerous studies in Zambia have examined the effects of climate change on agriculture, limited empirical evidence exists on the direct role of adaptation strategies in enhancing maize food security at the district level (Mundia et al., 2025). Most research tends to address adaptation and food security as separate issues, without fully exploring their interdependence in smallholder farming contexts. Kabwe District presents a particularly relevant case study given its dual exposure to climatic risks and its dependence on maize as both a subsistence and cash crop. Analyzing this relationship can provide actionable insights for policymakers, development agencies, and farming communities seeking to strengthen climate resilience while ensuring staple food security (Mundia et al., 2023).

This study aims to examine the role of climate change adaptation strategies in enhancing maize food security for smallholder farmers in Kabwe District, Zambia. Specifically, it seeks to identify the adaptation measures currently employed, assess their effectiveness, and analyze the factors influencing their adoption and impact (Sianungu., 2021). By integrating climate adaptation theory with food security frameworks, the research contributes to a deeper understanding of how smallholder farmers can sustainably respond to climate risks. The findings will not only enrich scholarly discourse on climate-resilient agriculture in sub-Saharan Africa but also inform the design of targeted interventions that enhance both adaptive capacity and food security in maize-dependent rural communities. (Simatele et al., 2021)

## II. LITERATURE REVIEW

### A. Introduction

This chapter presents a comprehensive review of literature and theories relevant to the study of smallholder adaptation strategies and their impact on maize food security. It delves into theoretical frameworks, existing studies, and research gaps to establish a foundation for understanding how adaptation strategies contribute to food security. The review also highlights the relationship between various independent variables, such as adaptation strategies effectiveness, challenges faced, and their influence on the dependent variable, maize food security.

### B. Climate Change and Food Security in Zambia

Training and development programs play a vital role in enhancing employee performance, creating opportunities for

growth, and improving organizational productivity. These initiatives are designed to equip employees with the skills and knowledge they need to excel in their roles while preparing them for future challenges. A well-executed training program not only benefits the organization but also fosters a sense of confidence, motivation, and job satisfaction among employees (Sianungu., 2021).

At Kansanshi Mine in the Solwezi District of Zambia, training and development are particularly crucial due to the technical and demanding nature of mining operations. Kansanshi Mine, being one of Africa's largest copper producers, requires a highly skilled workforce to sustain its competitive position in the global market. This case study delves into the effectiveness of Kansanshi Mine's training and development programs and their impact on employee performance. It aims to provide insights into how these initiatives can be refined to create a more dynamic and efficient workforce (Ngoma., 2021).

Agriculture is a cornerstone of Zambia's economic development. Globally, numerous nations have recently transformed their economies by pouring investment into this sector. For instance, the Netherlands and Denmark leveraged livestock production for growth, whereas the United States and India achieved success through diversified crop farming. Specifically, India has attained food self-sufficiency and built the resilience needed to withstand environmental challenges by effectively integrating crop diversification, advanced research, extension services, and consistent input supplies (Hazra, 2002).

Climate change represents one of the most significant threats to humanity today, with far-reaching consequences across all economic sectors. In low-income nations, weak adaptive capacity and limited awareness have worsened poverty among vulnerable populations (Anderson, 2010). Research indicates that persistent droughts have slashed crop yields, particularly for small-scale farmers, while water scarcity and moisture stress have crippled both plant and livestock production (Rosen et al., 2021; Nhamo et al., 2018). Consequently, traditional rain-fed farming is struggling to remain viable. Driven by the greenhouse effect and fluctuations in solar energy, rising global temperatures are disrupting the water cycle and natural life patterns (Gannon et al., 2014). Ultimately, these environmental shifts degrade agricultural productivity, undermining food security and the socio-economic stability of entire regions (De Brooke et al., 2023).

Zambia's climate is characterized by a dry period, which runs from May to October, and a wet period that runs from November to April. Because most of the country's agriculture is rain fed, rainfall variability poses challenges for food security and planning. Agriculture accounts for about 3.39 percent of Gross Domestic Product (GDP), with maize as the dominant crop (the other main crops are wheat, sorghum, cassava, rice, millet, groundnuts, soybeans, mixed beans, peanuts, sunflower seed, vegetables, coffee, flowers, tobacco, cotton, and sugarcane). (Makondo et al., 2014). Agricultural jobs account for 57.31% percent of employment in Zambia

and contributes about 80% of the total national food security. Based on global climate models we know that Sub-Saharan Africa (SSA) will be one of the most affected regions, with expected agricultural productivity decreases of up to 20% (for major food crops), and stubbornly high levels of poverty and food insecurity – especially in rural areas (Cline 2008). In spite of having relatively good rainfall compared to other parts of SSA, Zambia is highly exposed to climate change which exacerbates the changes in rainfall patterns and extreme weather events further increasing the high sensitivity of the agricultural sector (NCCRS 2010).

Zambia's climate is defined by a distinct dry season from May to October and a rainy season from November to April. Since the country's agricultural system is predominantly rain-fed, fluctuating precipitation patterns create significant hurdles for food security and strategic planning. Although agriculture contributes approximately 3.39% to the national GDP, it is a vital employer, supporting 57.31% of the workforce and providing 80% of Zambia's food security. Maize remains the primary crop, supplemented by a diverse range of others, including wheat, sorghum, cassava, and various legumes (Makondo et al., 2014).

Global climate projections suggest that Sub-Saharan Africa will face some of the world's harshest impacts, with potential 20% declines in major crop yields and persistent rural poverty (Cline, 2008). Despite its relatively favorable rainfall compared to regional neighbors, Zambia remains highly vulnerable; climate change is intensifying erratic weather and rainfall shifts, further straining the already sensitive agricultural sector (NCCRS, 2010)

In the last three decades, Zambia particularly its southern and central regions has experienced frequent rainfall irregularities and droughts, leading to a marked decline in maize production (Jain, 2007). While urban poverty has seen some improvement over the past 20 years, rural poverty remains stagnant at approximately 80%, and malnutrition rates have risen by 23% since 1990 (Chapoto et al., 2011; Garrity et al., 2010). Given that 75% of the farming population consists of subsistence farmers' dependent on rain-fed agriculture, improving food security requires a deep understanding of how both farming practices and climate shifts impact yields (Jain, 2007). Climate-Smart Agriculture (CSA) addresses these challenges by aiming to sustainably boost productivity and income, enhance climate resilience, and lower greenhouse gas emissions compared to traditional methods (FAO, 2013). However, developing a successful CSA strategy requires site-specific, rigorous research to identify the most effective practices for different climatic conditions.

### C. Empirical Review

#### ➤ Overview

The impact of climate change on food security is a growing concern, particularly for smallholder farmers who depend on rain-fed agriculture. Previous studies indicate that climate variability, including erratic rainfall and prolonged droughts, has significantly reduced crop yields in Zambia,

threatening household food security and livelihoods (Mundia et al. 2026).

Furthermore, while national-level studies on climate change effects exist, there is limited empirical research addressing the effect of the adaptation Strategies on food security of smallholder farmers specific to rural communities like those in Kabwe District. This gap is particularly significant given the district's reliance on smallholder farming as a primary livelihood. Therefore, this study seeks to explore the effectiveness of adaptation strategies in improving food security outcomes in this specific context, contributing to the broader understanding of climate resilience in rural Zambia.

#### ➤ Empirical Studies

##### • *Climate Change Adaptive Strategies of Smallholder Farmers*

Adapting to climate change and its associated risks occurs within a fluid environment shaped by social, economic, technological, biophysical, and political factors. These conditions, which change across different times, locations, and sectors, collectively determine a system's ability to adjust. Consequently, this adaptive capacity differs significantly between various regions, countries, and socioeconomic groups (Makondo et al., 2014)

Smallholder farmers globally have implemented various measures to counteract the negative impacts of climate change. These strategies include adopting conservation agriculture, agroforestry, and crop diversification, alongside utilizing drought-resistant seeds and advanced water management. For instance, practices like crop rotation and reduced tillage are promoted to boost soil fertility and moisture retention. Similarly, irrigation systems and rainwater harvesting have proven effective in building resilience against unpredictable rainfall.

Research by Mundia et al. (2023) in Ethiopia's Doba district further illustrates these trends, highlighting how smallholders adapt through diversified cropping, integrated livestock management, and off-farm income activities. Their study identifies several critical factors that influence a farmer's ability to adapt, including:

- Agro-ecological location and plot size.
- Socio-demographic factors such as gender and family size.
- Institutional support, specifically the frequency of training and contact with extension services.
- Economic resources, including livestock holdings and access to off-farm income

Smallholder farmers worldwide have adopted diverse strategies to mitigate the adverse effects of climate change. These include practices such as conservation agriculture, agroforestry, crop diversification, the use of drought-resistant seeds, and improved water management techniques. For example, reduced tillage and crop rotations have been promoted to enhance soil fertility and water retention

(Mundia et al. 2025). Similarly, rainwater harvesting and irrigation systems have shown potential in increasing resilience to erratic rainfall. Similarly, the finding of Mundia et al. (2023) studies on smallholder farmers' perceptions and adaptation to climate variability and climate change in Doba district, western Harerghe, Ethiopia. They investigated the determinant factors influencing adaptation strategies to climate variability and change. The adaptation strategies were crop diversification and the use of soil and water conservation practices, integrated crop and livestock diversification, engaging in off-farm income activities and rain water harvesting. The result revealed that agro-ecological location, sex, family size, plot size, off-farm income, livestock holding, frequency of extension contact and training are the determinant factors influencing adaptation strategies.

Furthermore, Tessema et al. (2013) explored how smallholders in Eastern Hararghe, Ethiopia, perceive and adapt to climate change. Utilizing a multinomial logit model, the study identified tree planting as the primary adaptation method, alongside early planting, terracing, irrigation, and water harvesting. Factors such as non-farm income, credit access, market proximity, and extension services significantly influenced these choices. Conversely, the study highlighted a lack of information as the main barrier to adaptation, followed by shortages in land, labor, capital, and water.

Similarly, Deressa et al. (2008) examined adaptation determinants in Ethiopia's Nile Basin. Their findings indicated that while farmers use diverse crop varieties, soil conservation, and irrigation, their choices are shaped by education, gender, household wealth, and social capital. Again, financial constraints and a lack of information emerged as the primary obstacles. Mundia et al. (2021) reinforced these findings in the same region, noting that while changing crop varieties is common, irrigation remains underutilized due to limited resources and technical knowledge.

While global and regional studies emphasize mixed farming and community resource management, there is a distinct lack of research focused on Kabwe District. Despite agriculture being the primary livelihood in Kabwe, localized adaptive practices remain under-studied. This research aims to fill that gap by investigating the specific strategies used by Kabwe's smallholders and evaluating their success in building climate resilience.

### III. METHODOLOGY

#### A. Introduction

This chapter of the study contains the research approach, research design, study sites, study population, Sampling Techniques, data collection and data analysis.

The insights from this study will help the policy makers, the smallholder farmers and the entire world to have an understanding of the prevailing adaptive strategies and best options strategies for enhancement of food security both at household by smallholder farmers and at national level.

#### ➤ *Research Methodology*

##### • *Research Approach*

Given the main objective of the present study, which was stated in the first chapter, it shows that the study is both quantitative and qualitative. Hence, mixed methods will be applied for data gathering. The mixed-methods approach, combines both quantitative and qualitative research designs. The quantitative component seeks to measure food security levels and assess the prevalence of climate change adaptation practices among smallholder farmers. The qualitative component aims to explore in-depth the contextual experiences, perceptions, and socio-cultural factors influencing adaptation strategies.

##### • *Research Design*

This study will adopt a *Explanatory Sequential design*, to examine the relationship between climate change adaptation and food security among smallholder farmers in selected rural communities of Kabwe District, Zambia. The design is selected to allow a broad understanding of the quantitative status of adaptation and food security, followed by an in-depth qualitative exploration of the contextual, social, and institutional factors influencing these outcomes.

#### B. *Data Generation*

##### ➤ *Qualitative Data Generation Process*

Data saturation is a guiding principle in qualitative research that refers to the point at which additional data collection no longer yields new information, themes, or insights. In this study, data saturation will be considered achieved when the same themes, adaptation strategies, and food security issues begin to recur consistently across interviews.

In qualitative research, sample size is not determined through statistical formulas aimed at generalizability, but rather through the goal of obtaining rich, in-depth, and diverse data that sufficiently captures the experiences and perspectives of participants. An appropriate framework for estimating a qualitative sample size is Guest, Bunce, and Johnson's (2006) recommendation, which suggests that a minimum of 12–20 interviews is often sufficient to reach data saturation when participants are relatively homogeneous in terms of experience or context. Thus, approximately 12 participants will be interviewed, with flexibility to increase or reduce based on data saturation. To monitor saturation, interviews will be analyzed concurrently with data collection. If by the 13<sup>th</sup> to 20<sup>th</sup> interview no new insights emerge, saturation will be considered achieved.

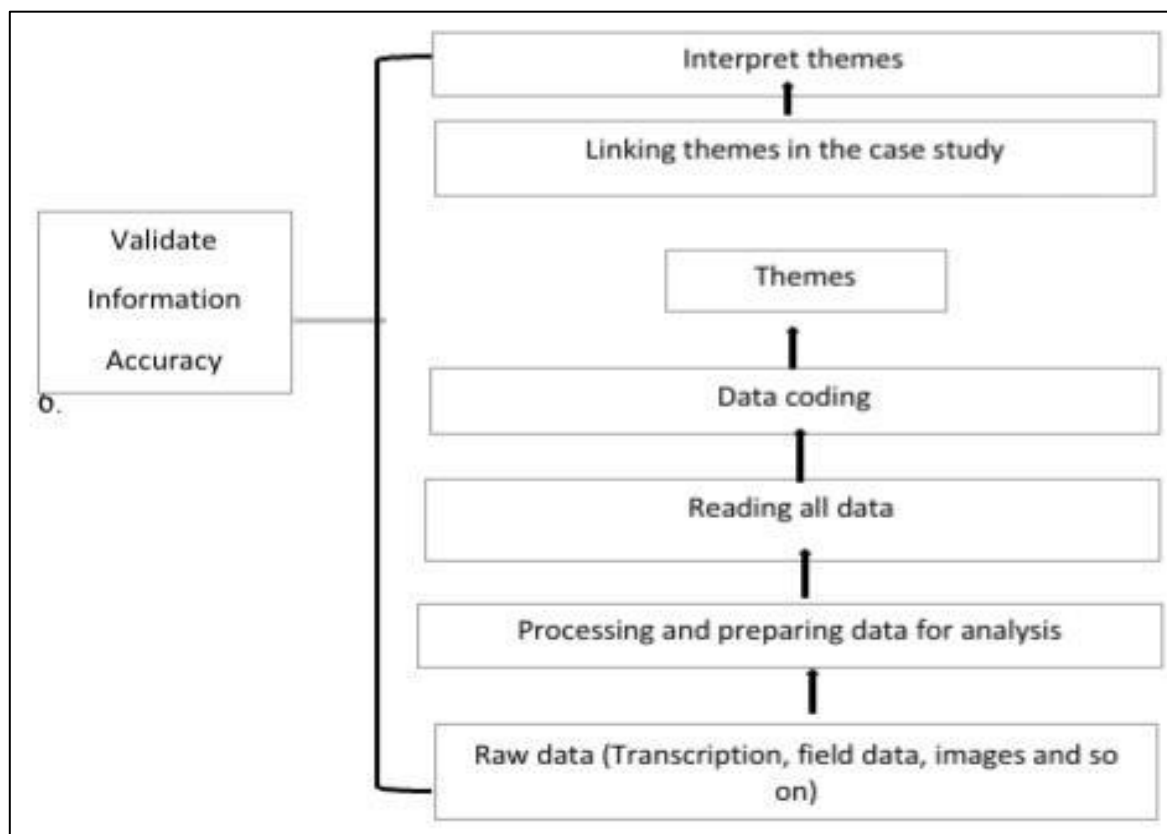


Fig 1 Data Generation Process (Creswell, 2008)

➤ *Data Collection Methods*

This study will employ both qualitative and quantitative data collection methods as recommended by Neuman [27]. Data will be collected through, structured Surveys and key informant interviews with smallholder farmers selected from the five rural communities (Kafulamase, Mpima, Kaputula, Kamupompi, and Chowa). Interviews discussions will facilitate collective insights, encouraging participants to share diverse perspectives and solutions.

• *Surveys*

Data at the household level will be collected through a household survey using structured questionnaires. These will initially be pretested to check their validity and appropriateness. For pretesting the questionnaire, nine households from non-sampled will be identified and interviewed prior to the actual interview of the target sample households. This will allow the restructuring of questions before intensive data collection. Based on the limitations identified in the pretest, the questionnaires will then be amended and enriched for the actual interview.

• *Interviews*

“Interviewing is the one most common and most powerful way we use to try to understand our fellow human beings” (Fontana and Frey, 1994:361). The purpose of interviewing is to find out peoples’ experience within the topic under study. There are many interview forms, each differ from the other in structure depending on the purpose of the research topic, objectives, and resources available. For instance, there are structured, unstructured or semi structured interviews.

Structured interview refers to a situation whereby an interviewer asks an interviewee pre-established series of questions with limited set of alternatives. She or he reads out the prepared questions as they are in the interview schedule. By using this form, all respondents receive the same set of questions and in the same sequence. However, there is little flexibility because there is no freedom to make adjustments to any of the components, such as content, wording, and order of the questions. Unstructured interview is the kind of interview whereby there are no restrictions in the wording of questions, the sequence of questions or following interview schedule. The structures of these interviews are flexible with minimal restrictions. An interviewer can probe or prompt the respondents. Semi-structured interviews contain elements of both structured and unstructured interviews (Fontana et al., 1994; Sarantakos, 1998).

Taking into account the main objective of the study, this research proposal will employ the unstructured interview method as it helps to gain the most insight. As Kvale (1996:129) puts it, “A good interview question should contribute thematically to knowledge production and dynamically to promoting a good interview interaction.”

Therefore, interview guides will be administered to ten (10) farmers and agricultural officers collectively, working in the region. This will provide qualitative insights into local adaptation strategies and challenges.

### ➤ *Data Collection Tools*

- Semi-structured interview guides will be developed for interviews. These guides will include open-ended questions and thematic prompts aligned with the research objectives.
- Audio recorders (with consent) will be used to capture conversations.
- Field notebooks will be used to document non-verbal cues, contextual observations, and reflections during data collection.
- Questionnaires; A structured questionnaire to households will be used to collect quantitative. The Oxford Advanced Learners' Dictionary (2010) defined questionnaire as a written or printed list of questions to be answered by a number of people especially as part of survey. This technique will involve written questions to which the respondents will be required to write answers individually with no researcher's guide.

### C. *Population*

The research will focus on five (5) rural communities in Kabwe District, Zambia, characterized by smallholder farming as the primary livelihood activity. These rural communities are, Kafulamase, Mpima, kaputula, Kamupompi and Chowa.

The study population for this research will comprise of smallholder farmers in Kafulamase, Mpima, Kaputula, Kamupompi and Chowa rural communities of Kabwe. These five communities have been selected because they are mostly affected by the climate change effects e.g., prolonged draughts, extreme hot temperatures, and therefore understanding the adaptive strategies engaged by smallholder farmers would really contribute in solving the problem.

### D. *Sampling Techniques*

The sampling techniques applied in this research are non-probability and random sampling. The examples of non-probability sampling are; purposive sampling, snowball sampling, and quota sampling (Bryman, 2004; Silverman, 2005). This study will employ a multi-staged sampling technique, where a combination of sampling techniques will be used to select the five communities and the participants. In the first stage, the five communities, kamupompi, kafulamase, Mpima, Chowa and Kaputula will be selected purposely from the district of Kabwe, because it is one of the most severely affected districts by extreme climate change-related risks and is characterized by heavy smallholder farming. In the second stage, the smallholder farmers and key informants will be selected randomly with the assumption that smallholder farmers within each community may have differences in their traditional knowledge and skills, and that this may result in different adaptive capacities in the communities.

### ➤ *Therefore, Two Levels of Sampling will be Used:*

- Purposive Sampling: Rural communities that have experienced noticeable climate variability and where

smallholder farming is the primary livelihood source will be selected using purposive sampling

- Random Sampling: Within these communities, smallholder farmers and key informants of diverse gender, age, and socio-economic status will be selected using random sampling to ensure a wide range of perspectives

The reason behind using purposive sampling in qualitative research is, to obtain rich and detailed answers in order to explain, describe, and explore the social behaviors (Patton, 1990; Bryman, 2004). In this study, efforts will be made to explore how smallholder farmers in kabwe are adapting to climate change. Information about this issue cannot be gathered just from anybody. That is why purposive sampling will be employed. Sarantakos (1998:152) explains the following concerning purposive sampling; *The researchers purposely choose subjects who, in their opinion, are thought to be relevant to the research topic.*

Yet, Patton (1990) puts forward the argument that applying purposive sampling without including random procedures can bring doubts about why certain cases were chosen for study. He alerts that, although random sampling is important in purposive sampling, it is not for the purpose of representativeness but credibility. He says; *It is critical to understand, however, that this is a purposeful random sample, not a representative random sample. The purpose of a small random sample is credibility, not representativeness (Patton, 1990:180).*

In order to avoid suspicion as Patton puts it, the selection of smallholder farmers and key informants within the selected communities will be selected randomly.

Sample Size: For this study, a sample size of 88 participants was determined using Cochran's formula, with the following assumptions: a 95% confidence level, a 10% margin of error, and an estimated population proportion of 0.5. This sample size is based on a population of 1,000 individuals and accounts for finite population correction. The calculated sample size ensures that the results will be statistically reliable within the specified margin of error.

### E. *Data Analysis*

Data analysis is a critical component of the research process, as it transforms raw data into meaningful insights that address the research objectives and questions. Raw data do not make any sense without being analyzed. Data analysis involves making sense out of the raw data, integrating and organizing what different people have said, and connecting peoples' experiences into major themes. Although data analysis deals with collected data, it is difficult to demarcate where data collection activity ends and data analysis begins. This is so because data analysis starts in the field. It is part and parcel of data collection (Patton, 1990; Potter, 1996; Sarantakos, 1998; Silverman, 2005).

### ➤ *Quantitative Data Analysis*

Quantitative data will be analyzed using SPSS or Stata. Analysis will involve:

- Descriptive statistics: Means, frequencies, and percentages to summarize household characteristics, food security levels, and adaptation practices.
- Cross-tabulations: To assess relationships between variables (e.g., adaptation strategy and food security status).

➤ *Qualitative Data Analysis*

Qualitative data from Key informant interviews will be transcribed, translated (if necessary), and analyzed using thematic analysis. Key steps include:

- Familiarization with data
- Coding and categorization
- Identification of themes and patterns
- Interpretation in relation to research objectives

Analysis may be supported by software like NVivo or done manually using matrices and charts.

**IV. PRESENTATION OF THE FINDINGS**

*A. Introduction*

This chapter presents a comprehensive and detailed analysis of the research findings based on both quantitative data from questionnaires and qualitative insights from interviews. A total of 78 smallholder farmers participated in the survey, and 10 were interviewed. The study focused on assessing the use, effectiveness, and challenges of adaptation strategies such as minimum tillage, drought-resistant seeds, and leaf pruning in relation to maize productivity and household food security in Kabwe District. Each research question is discussed in-depth, with separate sections for quantitative and qualitative responses to provide a holistic understanding.

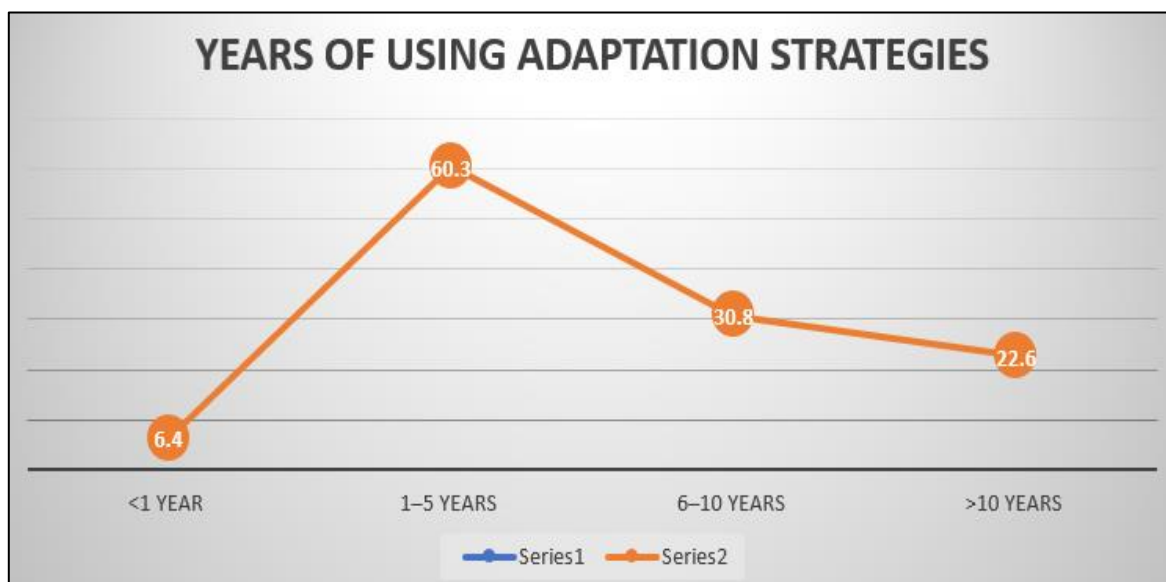


Fig 2 Years Using Adaptation Strategies

Most farmers (60.3%) had used adaptation strategies for 1–5 years, while 30.8% had done so for 6–10 years. Only 22.6% had practiced them for over 10 years. This indicates

that adoption is a relatively recent trend, possibly driven by increasing climate stress or recent extension programs.

Table 1 Effectiveness of Strategies

Perceived Effectiveness	Frequency	Percentage (%)
Very Effective	63	80.8
Moderately Effective	11	14.1
Not Effective	4	5.1

According to the survey, 80.8% of the respondents rated the strategies as very effective, while 14.1% found them moderately effective. Only 5.1% said they were not effective. This distribution underscores strong perceived benefits, likely reflecting yield improvements, better soil moisture retention, and resistance to erratic weather.

The high perception of effectiveness signals that smallholder farmers value these strategies as viable responses to climate change. The widespread satisfaction also indicates the potential for scaling up adoption, particularly through cooperatives and extension programs.

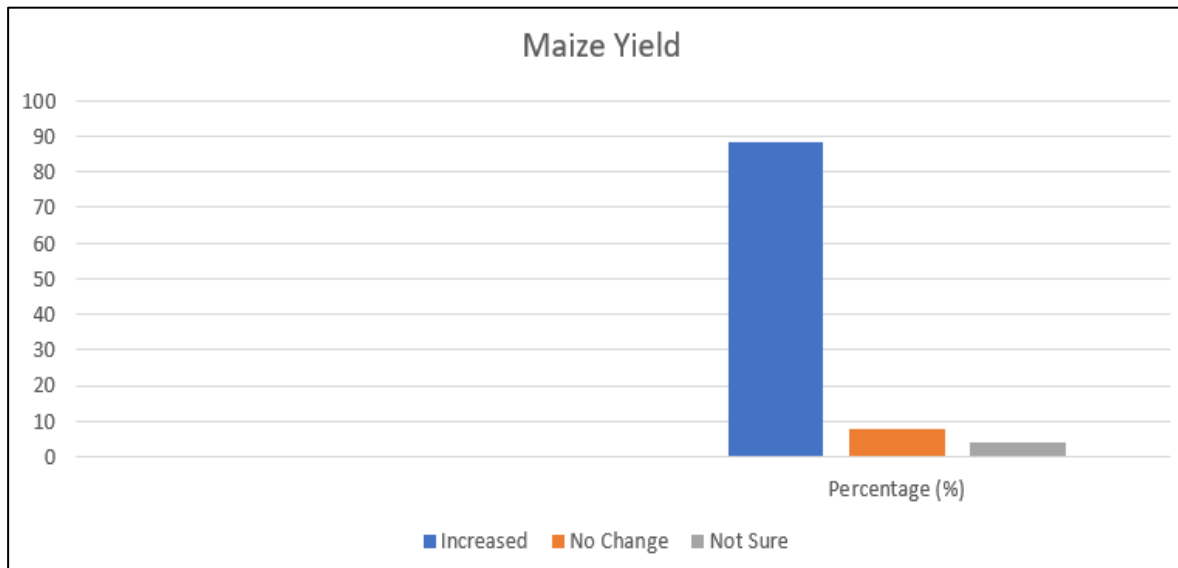


Fig 3 Reported Changes in Maize Yield

A resounding 88.5% of farmers reported yield increases after adopting adaptation strategies. Only 7.7% reported no change, while 3.8% were unsure. This outcome strongly supports the hypothesis that conservation practices lead to improved maize production.

This finding is critical because yield is a key indicator of food security. Higher production directly translates into more household maize supply and possible surplus for sale or storage.

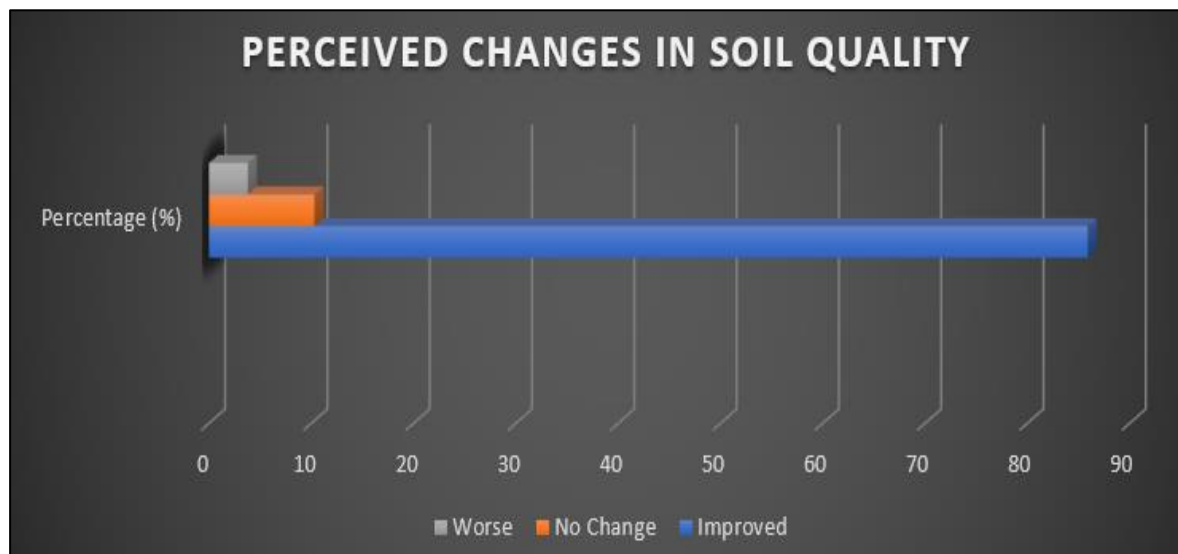


Fig 4 Perceived Changes in Soil Quality

86 % of farmers believed that soil quality had improved, while 10.3% said it remained the same and only 3.8% said it worsened. This is important because conservation practices

like minimum tillage and crop cover are known to restore organic content and retain moisture.

Table 2 Input Cost Reductions

Response	Frequency	Percentage (%)
Yes	66	84.6
No	10	12.8
Not Sure	2	2.6

A total of 84.6% of farmers reported reduced input costs. This is likely due to less ploughing, and minimized

need for chemical fertilizers. A smaller group (12.8%) reported no cost reduction, and 2.6% were unsure.

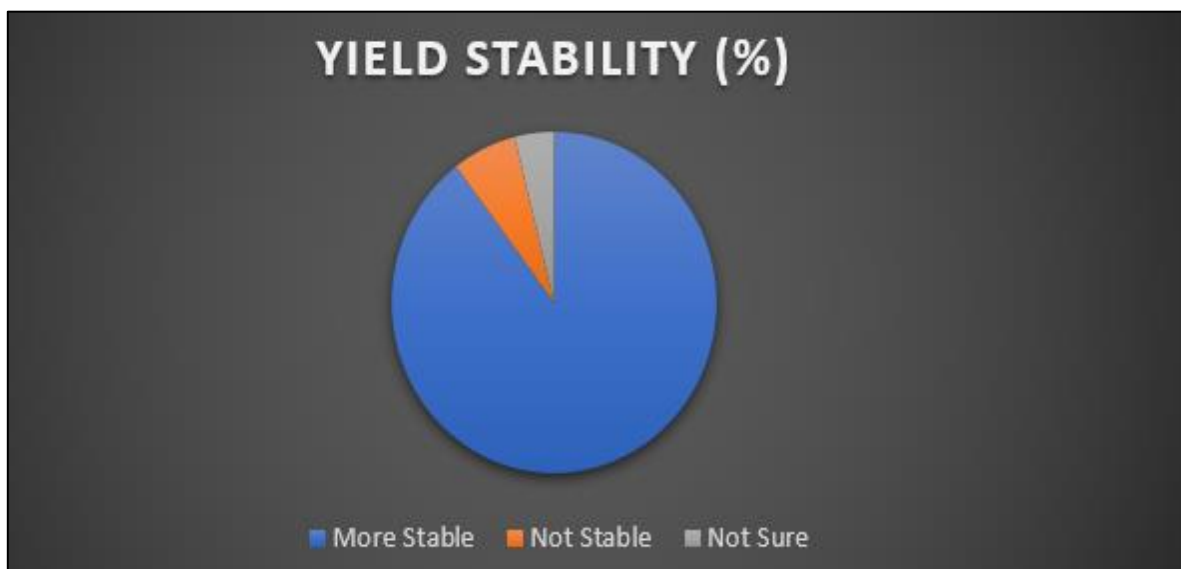


Fig 5 Yield Stability Across Seasons

➤ *Quantitative Analysis:*

About 90% of farmers said that their maize yields were more stable after adopting adaptation strategies. Only 6.4% disagreed and 3.6% were unsure. Stable yields reduce seasonal hunger and make farming more predictable.

These responses indicate that adaptation strategies are reducing the volatility of crop output, which is especially

critical in areas affected by rainfall irregularities. Yield stability is a strong indicator of resilience.

This evidence suggests that farmers are not just seeing higher yields, but more consistent ones. This adds another layer of food security and strengthens the case for promoting adaptation broadly.

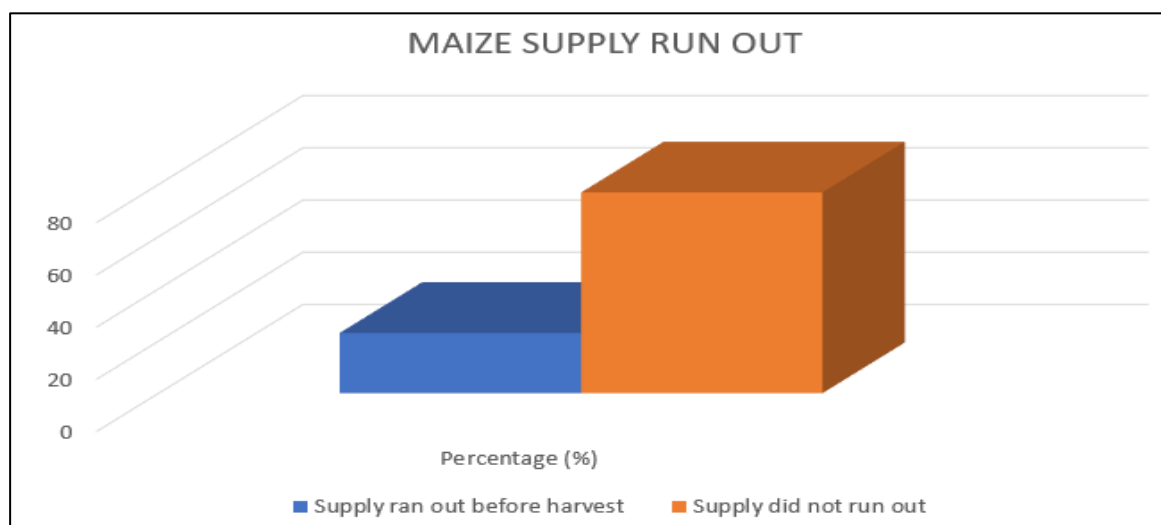


Fig 6 Maize Supply Status Before Next Harvest

This question provides a direct measure of household food self-sufficiency in relation to maize, the staple crop. The data shows that 76.9% of respondents (60 out of 78) reported that their maize supply lasted through the growing season, suggesting effective storage and yield management. This result reinforces the idea that adaptation strategies, such as improved seed selection and moisture conservation, are successfully mitigating climate risks and supporting long-term food security for most smallholder households. However, the 23.1% of respondents who reported maize shortages still highlight a minority vulnerable group needing targeted intervention.

B. *Qualitative Findings*

➤ *Objective One: Effectiveness of Adaptation Strategies Used*

• *Theme 1: Minimum Tillage*

Minimum tillage was adopted by a number of farmers as a conservation technique aimed at reducing land degradation and preserving soil moisture. Those who practiced it consistently observed that it improved the resilience of their maize crops during dry periods. As one respondent explained, “I no longer disturb the soil too much;

*just a small hole is enough. This way, the moisture stays longer.*" This strategy has helped maintain soil structure and reduce runoff, thus increasing the chances of a successful harvest, especially during erratic rainfall periods.

- **Theme 2: Drought-Resistant and Early-Maturing Seeds**

The adoption of drought-resistant and early-maturing maize seeds has significantly contributed to improved productivity under unpredictable climate conditions. Many farmers confirmed that these seeds enable crops to mature before rains end abruptly. As one farmer noted, *"We use early maturing seeds now because we know rains are not reliable anymore. They grow fast and we harvest before it's too late."* These seeds have proven particularly useful for households struggling to secure consistent yields in the face of climate change.

- **Objective Two: Challenges Faced in Using Adaptation Strategies**

- **Theme 3: High Cost of Inputs**

One of the major barriers to implementing adaptation strategies is the high cost of agricultural inputs such as fertilizers and improved seed varieties. Farmers repeatedly expressed frustration with their inability to afford these crucial resources. As one participant lamented, *"We want to use good seed, but it's too expensive for many of us."* This cost barrier undermines efforts to achieve widespread adoption of effective strategies.

- **Theme 4: Lack of Tools and Equipment for Minimum Tillage**

While minimum tillage has proven effective, farmers face difficulties due to the unavailability of proper tools and implements. Many are forced to rely on traditional hoes, which are not well-suited for conservation agriculture techniques. One respondent shared, *"We hear about ripping and minimum tillage, but we have no tools. It's hard to do it properly with a hoe."* This challenge limits the scalability and consistent application of minimum tillage across farming households.

- **Theme 5: Extension Service Gaps and Knowledge Constraints**

The implementation of adaptation strategies is further hampered by a lack of adequate extension services. Farmers reported minimal interaction with agricultural officers, leading to limited technical support. Despite strong peer-to-peer knowledge transfer, institutional backing is weak. As one farmer stated, *"We only see extension officers maybe thrice a year... if at all."* This gap restricts farmers' ability to optimize or expand the use of adaptive practices.

## V. CONCLUSION

In conclusion, the study affirms that adaptation strategies such as minimum tillage and drought-tolerant seeds hold significant potential to improve maize food security in Kabwe District. These strategies have enabled farmers to enhance yields, maintain soil health, and achieve greater food availability and resilience.

However, the study also concludes that these benefits coexist with notable constraints, particularly related to institutional gaps, high input costs, and inequitable access to resources.

The study summarizes that while the findings align with many empirical studies across the region, contrasts with other cases point to the critical role of local context in shaping adaptation outcomes. The study underscores that adaptation is not only a technical process but also a social one, deeply influenced by education, gender, access, and support structures.

This study finally emphasizes that to sustain these gains, policymakers and development partners must prioritize investment in inclusive agricultural extension, subsidies for essential inputs, and gender-sensitive adaptation support systems. Only through such comprehensive frameworks can the potential of smallholder adaptation be fully realized and food security in vulnerable communities be secured long-term.

## RECOMMENDATIONS

Based on the study's findings, the following recommendations are made to policymakers, NGOs, extension workers, and farmer groups:

- **Strengthen Agricultural Extension Services:** Expand training programs and increase the frequency of field visits. Ensure extension staff are well-equipped to demonstrate adaptation strategies and monitor farmer progress throughout the agricultural season.
- **Improve Access to Agricultural Tools and Inputs:** Offer subsidies, vouchers, or cooperative-based lending systems for rippers, planters, and herbicide sprayers. This support should be targeted at vulnerable groups, including women.
- **Enhance Weed Management Support:** Develop and promote cost-effective weed control techniques compatible with conservation farming. Introduce group-based spraying services to reduce the cost burden on individual farmers.
- **Ensure Timely Distribution of Certified Seeds:** Work with seed suppliers and the Farmer Input Support Programme (FISP) to improve the timely delivery of drought-tolerant and high-yielding maize varieties.
- **Develop Monitoring and Re-adoption Frameworks:** Create a feedback mechanism to track strategy use, reasons for abandonment, and farmer re-engagement.
- **Foster Cooperative-Based Equipment Sharing Models:** Promote village-based equipment banks where groups of farmers can access tools collectively. This can also create income opportunities for tool maintenance and rental services.
- **Improve Policy Coordination:** Align local government initiatives with national agricultural strategies to ensure consistent resource flows and avoid duplication of efforts.

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