Int. j. adv. multidisc. res. stud. 2026; 6(1):256-269

Received: 18-11-2025
Accepted: 28-12-2025

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Examining the Effects of Drought on Maize Production: A Case Study of Small-Scale Maize Farmers in Munga Ward, Kabwe District

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Abstract
This study examined the effects of drought on maize production among small-scale farmers in Munga Ward, Kabwe District, with a focus on three objectives: to establish the effects of drought on crop viability, to examine its impact on household food security, and to identify adaptation strategies employed by farmers to mitigate these effects. Guided by the Sustainable Livelihoods Framework, the study adopted a mixed-method approach that integrated both quantitative and qualitative data to provide a holistic understanding of drought impacts. A total of 80 small-scale maize farmers were purposively selected from a population of 160. Data were collected using structured questionnaires and semi-structured interviews, and analyzed using Stata and Microsoft Excel for descriptive statistics and thematic interpretation. The findings revealed that over 50% of respondents experienced a significant decline in maize yields over the past five years, with most reporting 40–60% losses due to recurrent drought. Furthermore, 57% of households faced reduced food availability, struggling to meet food needs for up to five months annually, while 47% experienced a decline in dietary diversity and nutrition. Farmers adopted coping strategies such as drought-tolerant seed varieties, mulching, and conservation agriculture, though their effectiveness was limited by financial constraints, poor access to inputs, and weak extension support. The study concludes that drought poses a critical threat to maize viability and food security, emphasizing the need for climate-smart agriculture, improved access to irrigation, credit, and farmer training to enhance drought resilience and sustainable livelihoods.

Keywords: Drought, Maize Production, Food Security, Adaptation Strategies, Small-Scale Farmers, Sustainable Livelihoods Framework, Kabwe District, Zambia

1. Introduction

Maize is a staple crop for billions worldwide, particularly in developing regions, where it supports food security and rural livelihoods. Globally, maize accounts for over 30% of cereal production, but its cultivation faces increasing threats from climate change, especially drought. Studies indicate that maize is more sensitive to water stress than other cereals, and droughts have caused significant yield reductions. The Intergovernmental Panel on Climate Change (IPCC) warns that, without adaptation, climate-induced droughts could reduce global maize production by up to 24% by 2050, posing serious risks to food availability and economic stability, particularly in rain-fed agricultural regions.

Africa is highly vulnerable to these climatic shocks. Its maize sector is dominated by smallholder farmers dependent on seasonal rainfall, with limited access to irrigation or modern farming technologies. Approximately 40% of Africa's maize-growing areas experience recurrent drought, causing yield losses of 20–50% (Fisher *et al.*, 2015). Events such as the 2015–2016 El Niño and the 2024 Southern African droughts have highlighted the continent's susceptibility, resulting in crop failures, food shortages, and increased reliance on imports. Maize is not only a dietary staple but also a primary source of income, making drought-induced crop losses particularly damaging for household food security and national economies.

Zambia, in Southern Africa, is one of Africa's leading maize producers, relying on the crop for both food and economic stability. Small-scale farmers, who contribute around 85% of maize production, dominate the sector. However, Zambia's dependence on rain-fed agriculture makes it highly sensitive to climate variability. In recent years, droughts have become more frequent and intense, with the 2024 season causing widespread crop wilting and, in some areas, total maize failure, according to the Zambian Ministry of Agriculture. These events have led to food insecurity, forcing households to adopt negative coping strategies, such as reducing meal frequency or selling productive assets, further entrenching poverty.

Drought impacts maize production at multiple levels. Stress during critical growth stages like flowering and grain filling reduces yields by impairing kernel development and lowering plant resilience to pests and diseases. Drought limits photosynthesis, water and nutrient uptake, and slows growth, especially during the seedling stage. At the household level, smaller harvests translate into food shortages, malnutrition, and increased economic vulnerability. Nationally, reduced output strains food reserves, increases dependence on costly imports, and undermines government efforts to achieve food self-sufficiency.

To mitigate drought impacts, small-scale farmers in Zambia and across Africa have adopted various adaptation strategies. These include using drought-tolerant maize varieties, conservation agriculture, crop diversification, and improved water management, such as rainwater harvesting. The Drought Tolerant Maize for Africa (DTMA) project, implemented by CIMMYT and the International Institute for Tropical Agriculture (IITA), has developed and disseminated drought-tolerant maize to benefit 30–40 million people across 13 African countries, including Zambia (Uiane *et al*., 2011; CIMMYT, 2023). These varieties can increase yields by 20–30% under moderate drought while offering resistance to major diseases (Fisher *et al*., 2015). Despite these benefits, adoption remains uneven due to limited access to quality seeds, inadequate extension services, and insufficient financial resources.

Given this context, examining drought effects on maize production among small-scale farmers in Kabwe District is critical. Kabwe, like many rural districts in Zambia, relies heavily on maize for food security and livelihoods. Understanding drought impacts on crop viability, household food security, and the adaptation strategies employed by local farmers provides valuable insights for policymakers, development practitioners, and farmers themselves. Such knowledge is essential for designing targeted interventions that enhance resilience and ensure sustainable maize production in the face of climate change.

1.2 General Objective

To examining the effects of drought on Maize production: A case study of small-scale maize farmers in Munga Ward.

1.2.1 Specific Objectives

1. To establish the effects of drought on crop viability among small scale maize farmers.
2. To examine the effects of drought on household food security among small-scale maize farmers.
3. To identify the adaptation strategies employed by small-scale maize farmers in mitigating drought.

1.3 Conceptual Framework

This shows the diagrammatic depiction of the relationship between commercial banks' capital financing and the variables (credit terms, interest rates, bank credit) with their indicators and the performance of SME determinants.

1.3.1 Sustainable Livelihoods Framework

The Sustainable Livelihoods Framework (SLF) is the most suitable theoretical model for examining the effects of drought on maize production among small-scale farmers in Kabwe District. Developed by the UK's Department for International Development (DFID), the SLF provides a holistic approach to understanding how rural households build and sustain their livelihoods amidst vulnerability. It highlights five key forms of capital natural, human, financial, physical, and social that households draw upon to survive and improve their well-being. In the context of this study, drought directly impacts natural capital (e.g., rainfall and soil moisture), thereby reducing crop viability, while indirectly affecting financial capital through reduced yields and income. The SLF also accounts for external shocks like climate variability and their influence on household resilience and food security.

Furthermore, the framework emphasizes the importance of livelihood strategies and the enabling environment, such as access to support services, adaptation technologies, and government interventions. This is particularly relevant in Kabwe, where small-scale farmers adopt various coping strategies such as conservation farming, crop diversification, and drought-resistant seed use in response to changing climatic conditions. The SLF will help guide the analysis of how these strategies are shaped by both internal household capacities and external institutional support. Overall, the framework offers a practical and comprehensive lens for assessing the impacts of drought on both maize production and household food security, while also identifying pathways for building resilience among vulnerable farming communities.

2. Literature Review

2.1 Effects of Drought on Crop Viability among Small-Scale Maize Farmers

Drought is among the most severe environmental stressors affecting agriculture worldwide, particularly in rain-fed systems dominated by small-scale farmers. In sub-Saharan Africa, rain-fed agriculture contributes up to 95% of total crop production, making it highly sensitive to water scarcity (FAO, 2021). Maize (Zea mays L.), a major staple crop, is particularly vulnerable to drought due to high water requirements during critical stages such as tasseling, silking, and grain filling. Crop viability the ability of a plant to germinate, grow, and yield under specific environmental conditions (Campos *et al*., 2004)—declines sharply under drought, which is increasing in frequency and intensity due to climate change. Evaluating its impacts on maize is thus crucial for food security research.

Drought interferes with nearly all physiological, biochemical, and morphological processes in plants. It limits water availability, disrupts nutrient uptake, and reduces photosynthesis, resulting in stunted growth, lower biomass, and decreased yields (Farooq *et al*., 2017). In Zambia, recurrent droughts since the early 2000s, often linked to El Niño events, have caused sharp declines in maize output (Mulenga *et al*., 2018). Understanding these impacts is essential for designing adaptive interventions that sustain crop viability and household livelihoods.

Physiologically, drought restricts water for metabolic activities. Plants reduce stomatal conductance to conserve water, but this also limits CO_2 uptake, lowering photosynthesis and carbohydrate synthesis (Dietz, 2021). Water stress triggers overproduction of reactive oxygen species (ROS), which damage membranes, proteins, and nucleic acids, causing oxidative stress and premature leaf senescence (Anjum *et al*., 2017; Santini *et al*., 2023). While antioxidant enzymes mitigate ROS, severe drought overwhelms these defenses, leading to irreversible tissue injury.

Morphologically, drought reduces leaf expansion, shortens internodes, and suppresses root elongation, decreasing photosynthetic surface area and nutrient uptake (Passioura, 2007). Maize plants become dwarfed and chlorotic, displaying leaf rolling, wilting, and premature senescence, which impairs kernel development and lowers yields. Reproductive stages are particularly sensitive, with drought during tasseling and silking reducing pollen viability and fertilization, resulting in barren ears (Cairns *et al*., 2012; Lobell *et al*., 2014). Global studies show drought reduces maize yields by 30–70% in Africa and 40% on average worldwide (Daryanto *et al*., 2016; Shiferaw *et al*., 2014).

In Zambia, maize occupies nearly 60% of cultivated land and provides over 70% of rural caloric intake (CSO, 2022). Recurrent droughts between 2015 and 2020 caused yield declines exceeding 45%, resulting in widespread food shortages and heightened household vulnerability (ZVAC, 2021) [53]. Drought also affects maize quality, reducing starch and protein content and increasing susceptibility to aflatoxins, which threaten health and market value (Nawaz *et al*., 2020; Hell & Mutegi, 2011).

The viability of maize under drought is constrained by socio-economic and institutional factors. Many small-scale farmers lack irrigation, drought-tolerant seeds, financial resources, extension support, and timely weather information. Less than 5% of farmers have access to irrigation, while adoption of improved drought-resistant varieties remains low due to cost and limited distribution (CSO, 2020 [7]; Chomba & Kalinda, 2015). Female-headed households are particularly vulnerable due to limited land, credit, and extension access (Beaman *et al*., 2014).

Soil degradation further exacerbates drought effects. Low organic matter and poor water-holding capacity reduce resilience, leading to shallow roots and faster moisture depletion (Vanlauwe *et al*., 2011; Rwomushana *et al*., 2016). Pests like Fall Armyworm compound stress during dry years, causing additional yield losses of up to 40% (Tembo *et al*., 2018) [36].

Efforts to enhance maize viability include the development and dissemination of drought-tolerant varieties through initiatives like the Drought Tolerant Maize for Africa (DTMA) project, which has shown yield improvements of 20–50% under drought (Setimela *et al*., 2017; CIMMYT, 2020). Conservation agriculture, soil fertility management, water harvesting, and early-maturing cultivars also support resilience. Indigenous knowledge, such as using environmental indicators to guide planting, complements scientific approaches but is insufficient alone (Kassie *et al*., 2013).

Regionally, Africa's small-scale farmers remain highly vulnerable due to institutional gaps, limited infrastructure, and poor access to climate-smart technologies. Drought has disrupted maize viability across East, West, and Southern Africa, with losses forcing farmers to shift to less water-intensive crops, migrate, or reduce cultivated areas (Omoyo *et al*., 2015; Traore *et al*., 2014; FAO, 2017). Enhancing maize resilience requires integrated strategies combining agronomic innovation, infrastructure investment, financial services, policy support, and farmer training.

In conclusion, drought severely undermines maize viability in Zambia and across Africa. Its effects span physiological, morphological, biochemical, and socio-economic dimensions, threatening household food security, income, and national food systems. Strengthening maize resilience demands both technological and institutional innovations, widespread adoption of drought-tolerant varieties, improved soil and water management, and targeted support for small-scale farmers, particularly vulnerable groups.

2.2 Effects of Drought on Household Food Security among Small-Scale Maize Farmers

Drought is recognized as one of the most severe climate-related disasters globally, profoundly affecting agricultural productivity, food systems, and household food security. Small-scale farming communities, heavily dependent on rain-fed agriculture, are particularly vulnerable. The Food and Agriculture Organization (FAO, 2021) estimates that 1.4 billion people globally rely on small-scale farming, with maize being a staple for over 300 million people in sub-Saharan Africa (Shiferaw *et al*., 2011). Maize production's dependence on rainfall means that drought undermines all four pillars of food security: availability, access, utilization, and stability (FAO, 2008) [11].

Globally, drought reduces yields, destabilizes food markets, erodes purchasing power, and deepens hunger. The Intergovernmental Panel on Climate Change (IPCC, 2022) [20] reports increased drought frequency and intensity, causing extensive crop losses. Small-scale farmers are particularly affected due to limited irrigation, inputs, and insurance. Reduced rainfall limits soil moisture, shortens growing seasons, and decreases maize yields, sometimes by 30–70% depending on timing and severity (Lobell *et al*., 2011 [23]; Cairns *et al*., 2012). In Central America's Dry Corridor, repeated droughts since 2014 caused losses of up to 80%, increasing food insecurity by 30% (WFP, 2020).

Drought also undermines food access. Declining maize yields reduce both direct food sources and income from surplus sales. Scarcity inflates prices; during the 2015–2016 El Niño drought, maize prices in Malawi rose by over 60% (World Bank, 2016) [48]. Similar conditions in Zimbabwe, Zambia, and Ethiopia forced households to adopt coping strategies such as selling livestock or migrating for work (Devereux, 2018; Kulkarni *et al*., 2019 [22]). These shocks deepen poverty, restricting the ability to secure sufficient food.

Food utilization suffers as drought limits diet diversity. Households often rely solely on maize, lacking proteins and micronutrients, which increases malnutrition risk (UNICEF, 2022 [41]; HLPE, 2020). Consumption of moldy or aflatoxin-contaminated maize further harms health (Hell & Mutegi, 2011; Williams *et al*., 2019). Repeated droughts compromise stability, eroding household resilience and creating "food poverty traps" (Verner *et al*., 2018) [43]. In Zambia, recurring droughts from 2015–2020 reduced maize production by up to 45% and left millions reliant on food relief (ZVAC, 2021) [53].

Women and children are disproportionately affected. Women, responsible for food production and nutrition, face increased workloads and limited resource access, while girls are often withdrawn from school (Quisumbing *et al*., 2014; Mufungulwa *et al*., 2020) [30, 27]. Conflict and displacement exacerbate vulnerability; in the Sahel and Middle East, drought and conflict left millions food insecure (FAO & WFP, 2023) [14].

Mitigation strategies include early warning systems, social protection programs, and climate-smart agriculture. FEWS

NET provides rainfall and crop forecasts for planning (Hillbruner & Moloney, 2012). Conservation agriculture and drought-tolerant maize varieties improve yields during dry periods, as observed in Zimbabwe and Eastern Africa (Mazvimavi & Twomlow, 2009; Tesfaye *et al*., 2017) [24, 38]. Social protection initiatives like Ethiopia's Productive Safety Net Programme maintain food consumption and nutrition during drought (Berhane *et al*., 2014) [5]. Community-based approaches, such as seed banks and savings groups, enhance local resilience.

In Zambia, small-scale maize farmers produce 80% of national maize, largely rain-fed, making them highly vulnerable to drought (Sitko *et al*., 2019) [34]. Droughts in 2018–2020 led to acute food insecurity for over 2.3 million people (DMMU, 2020) [10]. Households reduced meals, relied on single-crop diets, and faced inflated maize prices of over 60% (CSO, 2020; ZVAC, 2021) [7, 53]. Structural challenges, including low adoption of drought-tolerant seeds (25% in some wards), limit adaptive capacity (Kasoma, 2023) [21]. Government interventions like the Food Reserve Agency, emergency food aid, and promotion of climate-resilient agriculture provide relief but often inadequately target the most vulnerable (WFP, 2020; IAPRI, 2022 [19]).

In conclusion, drought in Zambia and across sub-Saharan Africa significantly threatens household food security through diminished availability, restricted access, poor nutrition, and instability. Women, children, and poor households bear the greatest burden. Effective responses require integrated strategies combining climate-resilient agriculture, social protection, gender-sensitive interventions, and robust early warning systems to safeguard vulnerable maize-dependent communities.

2.3 Adaptation Strategies by Small-Scale Maize Farmers in Mitigating Drought

Small-scale maize farmers worldwide increasingly face frequent and severe droughts due to climate change, threatening food production, livelihoods, and agricultural systems. To mitigate these risks, farmers have adopted diverse adaptation strategies, including agronomic techniques, crop and seed innovations, water and soil management, livelihood diversification, and institutional interventions. The effectiveness of these strategies varies according to ecological zones, resource availability, and policy frameworks.

One of the most prominent global strategies is the adoption of drought-tolerant maize varieties. Institutions such as the International Maize and Wheat Improvement Center (CIMMYT) have developed cultivars with early maturity, heat tolerance, and higher water-use efficiency. In sub-Saharan Africa, Latin America, and South Asia, these varieties have enhanced resilience, with yield improvements of 20–30% under moderate drought conditions (Cairns *et al*., 2013) [6]. Government seed subsidy programs in countries such as Mexico and India have further enabled smallholders to access high-yielding, stress-tolerant maize, reducing vulnerability to dry spells.

Conservation agriculture (CA) is another widely promoted strategy. Practices such as minimal or zero tillage, permanent soil cover, and crop rotation improve soil structure, enhance moisture retention, and reduce erosion. Research shows that CA improves yields in water-stressed environments by increasing soil organic matter and retaining moisture (Thierfelder & Wall, 2010) [37]. In Zimbabwe and Zambia, farmers using conservation agriculture reported better crop performance during drought seasons, though adoption remains constrained by labor requirements, equipment costs, and limited extension support.

Water harvesting and soil moisture management techniques, including mulching, contour bunds, zai pits, and check dams, are critical for drought adaptation. In India, traditional systems like johads and check dams store water and recharge groundwater for smallholder irrigation (Agarwal & Narain, 2012) [2]. In West Africa, zai pits have increased maize yields by up to 120% in dry regions (Reij *et al*., 2009) [32]. These low-cost, locally adaptable practices face challenges of labor intensity and knowledge dissemination.

Crop and livelihood diversification help spread climatic risk. Intercropping maize with legumes such as cowpeas or pigeon peas improves soil fertility, dietary diversity, and income resilience (Snapp *et al*., 2010) [35]. Traditional systems like Latin America's milpa buffer against crop failure. Beyond farming, households engage in off-farm income generation, including petty trade, wage labor, and seasonal migration, which cushions the impact of drought but may be limited by mobility and skills (Dercon *et al*., 2011) [9].

Access to timely weather information and early warning systems supports informed decision-making regarding planting, input application, and harvesting. Agro-meteorological advisory services, mobile-based alerts, and community radios have reached millions of smallholders in India, Malawi, and Tanzania (Rao *et al*., 2015) [31], although digital literacy, language, and infrastructure barriers limit effectiveness in many areas.

Institutional support, including extension services, microfinance, insurance schemes, and social protection programs, further enhances adaptation. Micro-irrigation technologies and index-based weather insurance have been piloted in Kenya, Ethiopia, and India, while cash-for-work and food-for-assets programs strengthen community resilience (Hazell *et al*., 2010) [16]. Social capital through farmer groups, cooperatives, and community seed banks enables resource pooling, knowledge exchange, and access to inputs, as seen in Nepal, Bangladesh, and West Africa.

In Africa, smallholder maize farmers face additional constraints, including gender inequalities, limited credit, weak infrastructure, and policy inconsistencies. Women often experience restricted access to land, inputs, and decision-making, reducing their adaptive capacity (Carr & Onyekuru, 2016). Indigenous knowledge remains an essential complement to scientific innovations, guiding planting calendars, rainfall prediction, and soil management (Roncoli *et al*., 2002). Agroforestry, intercropping, and water conservation practices are increasingly adopted to enhance resilience, though uptake is often hindered by labor, land tenure insecurity, and extension limitations.

In Zambia, smallholder maize farmers are highly exposed to drought due to rain-fed agriculture. Strategies mirror global patterns, including drought-tolerant maize varieties, conservation agriculture, water harvesting, agroforestry, crop diversification, off-farm income generation, and irrigation where accessible. Institutional support through the Ministry of Agriculture, DMMU, FISP, and NGOs facilitates adaptation, although inefficiencies, limited targeting, and inadequate information access persist (Chisanga *et al*., 2022; Chapoto *et al*., 2019). Community-based approaches such as farmer field schools, village savings and loan associations, and cooperatives strengthen collective adaptive capacity and social capital, particularly for women-headed households.

Education and access to climate information are critical enablers. Farmers with higher literacy and exposure to climate-smart advisory services adopt innovations more readily. Integrating indigenous knowledge with formal extension, promoting gender equity, improving infrastructure, and expanding access to finance are essential to enhance the adaptive capacity of Zambian smallholders.

In conclusion, small-scale maize farmers globally, in Africa, and in Zambia employ a broad spectrum of strategies to manage drought risks. While effective in specific contexts, success depends on supportive policies, financial inclusion, extension services, gender-sensitive approaches, and the valorization of local knowledge. Strengthening these enabling conditions is key to sustaining maize production, food security, and rural livelihoods under increasing climate variability.

2.4 Literature Gap

While substantial research exists on drought and maize production in Sub-Saharan Africa, gaps remain when focusing on smallholder farmers in localized contexts such as Munga Ward. Most studies use regional-level agronomic analyses or remote sensing to assess water stress impacts on maize yields (Tesfaye *et al*., 2022; FAO, 2021). Although useful for macro-level understanding, these approaches overlook local ecological variations, including soil fertility, farming practices, and microclimates, which critically influence maize viability at the household level. Consequently, ward-specific, farmer-level evidence is limited.

Similarly, literature on drought and household food security often relies on national or district indicators, neglecting intra-household dynamics such as gendered food access, dietary diversity, and seasonal consumption patterns (FSIN, 2023; Mulenga *et al*., 2021). Little is known about how smallholders cope immediately after poor harvests and how these experiences vary within households, creating a gap in micro-level evidence linking drought to household food security.

Adaptation strategies such as drought-tolerant maize, conservation agriculture, crop diversification, and water harvesting have been documented (Chisanga & Phiri, 2022; Nhemachena & Hassan, 2020). However, most studies catalogue strategies without assessing their context-specific feasibility, adoption barriers, or long-term effectiveness at ward or community levels. Moreover, few studies explain why certain interventions succeed in some smallholder settings but fail in others, limiting policy relevance.

Methodologically, prior research predominantly uses cross-sectional or secondary data, restricting the capture of seasonal and annual variability in drought impacts (World Bank, 2022; Makate, 2019). Mixed-method approaches combining agronomic, household, and narrative data are scarce. Addressing these gaps justifies the proposed ward-level study in Munga, which aims to link drought impacts, maize viability, household food security, and locally adopted adaptation strategies.

3. Research Methods

The study adopted a mixed-method approach, combining both quantitative and qualitative research techniques to gain a comprehensive understanding of how drought affects maize production. This design enabled triangulation of data, where quantitative findings provided measurable patterns and qualitative insights offered deeper context and understanding. The approach was suitable for addressing complex climate-related issues that required both statistical and narrative evidence (Creswell & Plano Clark, 2018).

3.1 Target Population

According to Saunders, Lewis, and Thornhill (2009), a population refers to the total group of individuals relevant to a research study. The target population for this study consisted of small-scale maize farmers in Kabwe District, Central Province, Zambia, who had been actively engaged in farming for at least three consecutive seasons and had experienced drought effects.

3.2 Sampling Design

The study used a purposive sampling method to select participants. This non-probability technique was appropriate for identifying respondents with specific knowledge and experience related to drought impacts on maize production. The farmers selected were those who were actively involved in maize farming and were situated in Munga ward of Kabwe District commonly affected by drought (Etikan, Musa & Alkassim, 2016).

3.3 Sample Size Determination

Sample size refers to the number of items to be selected from the population to constitute the sample, indicating how many units should be surveyed and interviewed (Kumar, 2005). To determine the sample size from the population of 160 small-scale maize farmers, the Taro Yameni formula was used as follows;

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

Where:

N= population of Study (160)
n= sample of study
(e)= level of significance
Note (e) = 0.05 (95% confidence level)

$$n = \frac{160}{1+160(0.05)^2}$$

$$n = \frac{160}{1 + 160(0.0025)}$$

$$n = \frac{160}{1 + 0.4}$$

$$n = \frac{160}{1.4}$$

$$n = 114$$

However, due to resource and time constraints, 80 small-scale maize farmers were selected, representing a substantial proportion of the population while remaining manageable for data collection and analysis. In addition, 1 key informant was purposively selected, bringing the total sample size to 81 respondents. This approach ensured that the study captured a representative range of perspectives from the farming community within the district.

3.4 Data Collection Methods

Two primary methods were used to collect data:

3.4.1 Questionnaires (Survey)

Structured questionnaires were administered to collect quantitative data on crop viability, food security, and the perceived effects of drought. The questions included closed-ended and scaled items, which allowed for statistical analysis of trends and relationships.

3.4.2 Interviews (Interview Guide)

Semi-structured interviews were conducted with a subset of farmers to gather qualitative data. These interviews provided insight into personal experiences, challenges, and adaptation strategies used by farmers in response to drought conditions. Open-ended questions elicited detailed responses and uncovered underlying themes.

3.5 Data Analysis

3.5.1 Qualitative analysis

The data collected through both questionnaires and interviews were analyzed using a mixed-methods approach, aligning with the study's research design. Quantitative data from structured questionnaires were processed using Stata and Microsoft Excel. Descriptive statistics including frequencies, percentages, means, and standard deviations were calculated to summarize respondent characteristics and views. Stata was also used to perform cross-tabulations and explore relationships between variables, while Excel facilitated the creation of tables, charts, and graphs for clear visual presentation of findings.

Qualitative data from interviews were analyzed thematically, following a systematic process of coding, categorization, and theme development. This enabled the identification of recurring patterns, experiences, and adaptation strategies among small-scale maize farmers. The thematic analysis allowed for contextual insights that complemented the quantitative results, providing a holistic understanding of drought impacts, household food security, and the effectiveness of locally adopted adaptation strategies.

By combining quantitative and qualitative analyses, the study ensured triangulation, enhancing the reliability and depth of the findings. Quantitative results quantified the prevalence and distribution of key phenomena, while qualitative insights explained underlying reasons, perceptions, and adaptive behaviors.

4. Findings and Results

4.1 Demographic Information

4.1.1 What is your gender?

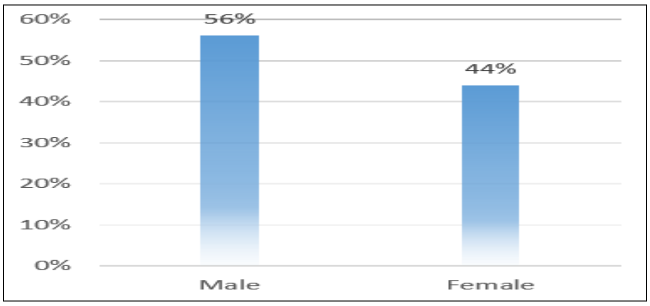

Fig 1: Gender

The gender distribution shows that male farmers (56%) slightly outnumber female farmers (44%) among the respondents. This indicates that maize production in Munga Ward is not exclusively male-dominated, as women also play a significant role in farming activities. The nearly balanced distribution suggests that drought impacts both genders almost equally, though women may face additional household responsibilities alongside farming. Therefore, it is evident that both male and female farmers are actively engaged in small-scale maize production and equally vulnerable to drought shocks. With these findings, the meaning is that any interventions aimed at mitigating drought effects must be gender-sensitive, ensuring both men and women farmers are adequately supported.

4.1.2 What is your age group?

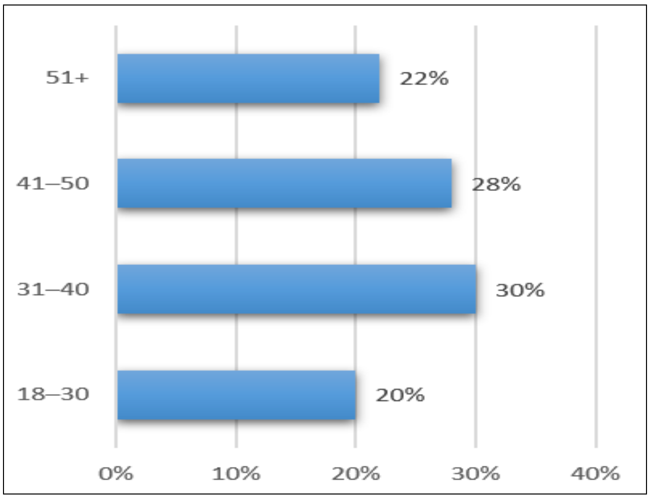

Fig 1: Respondent Age Groups

The age distribution reveals that the majority of respondents are between 31–40 years (30%) and 41–50 years (28%), representing the most active farming age groups. This suggests that maize farming in Munga Ward is largely carried out by middle-aged farmers who rely heavily on agriculture for their livelihoods. Younger farmers (20%) are also present, indicating that farming is still attracting a relatively youthful population despite the challenges of drought. Therefore, it is evident that drought resilience strategies should target middle-aged farmers, who constitute the majority, while also encouraging youth participation in climate-smart farming. With these findings, the meaning is that future agricultural interventions must engage farmers across all age groups to ensure sustainable adaptation practices are adopted.

4.1.3 What is your highest level of education?

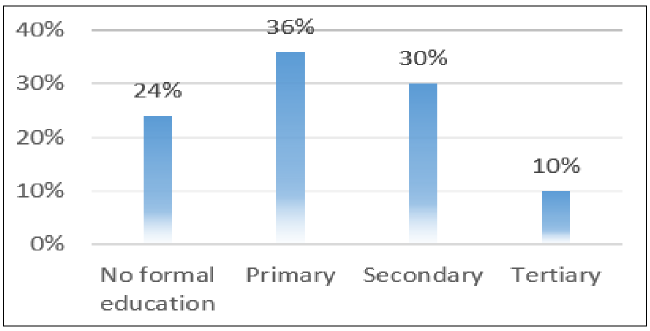

Fig 2: Respondents highest level of education

Education levels among farmers vary, with the majority having primary (36%) or secondary education (30%). A notable 24% have no formal education, which may limit their ability to access climate information, adopt new technologies, or benefit fully from government extension services. Only 10% reached tertiary education, showing that higher education is less common in small-scale farming communities. Therefore, it is evident that limited education may pose challenges to effective adaptation to drought, as understanding and implementing modern farming techniques requires literacy and awareness. With these findings, the meaning is that capacity-building initiatives and farmer training must be simplified and accessible to all education levels, especially those with little or no formal schooling.

4.1.4 Household Size

Table 1: Household Size

Household Size (Persons)	Frequency	Percentage (%)
1–3	8	10%
4–6	32	40%
7–9	28	35%
10 and above	12	15%
Total	**80**	**100%**

The findings show that the majority (40%) of small-scale maize farmers in Munga Ward have medium-sized households of between four and six members. Another 35% of respondents reported large households of seven to nine members, while only 10% had small families of three or fewer individuals. These results reflect a common demographic pattern in rural Zambia, where extended family systems and dependency ratios remain high. Such household sizes influence both labor availability for agricultural activities and food consumption needs, directly linking household composition to food security outcomes.

Therefore, it is evident that household size plays a crucial role in shaping the resilience of small-scale farmers to drought impacts. Larger households may have more labor to support production, but they also face increased food demand, making them more vulnerable during prolonged dry spells. On the other hand, smaller households may have limited labor for land preparation and drought mitigation strategies such as conservation farming. Hence, household size becomes a critical socioeconomic factor in understanding the dual challenges of maintaining productivity and ensuring household food security under drought conditions.

4.1.5 Farm Size (in Acres)

Table 2: Farm Size

Farm Size (Acres)	Frequency	Percentage (%)
Less than 2 acres	20	25%
2–4 acres	36	45%
5–7 acres	16	20%
8 acres and above	8	10%
Total	**80**	**100%**

The majority (45%) of farmers in the study cultivate between two and four acres of land, while 25% operate on plots smaller than two acres. Only 10% of respondents own relatively large farms of eight acres or more. This confirms that the farming community in Munga Ward is primarily composed of small-scale subsistence producers, consistent with national statistics indicating that over 70% of Zambia's maize farmers cultivate less than five hectares (MoA, 2023). Limited farm size directly restricts the ability of farmers to diversify crops, implement irrigation systems, or adopt large-scale conservation techniques that could mitigate drought effects.

Therefore, it is evident that landholding size significantly determines the adaptive capacity of small-scale farmers. Those with smaller farms are less likely to generate surplus production, limiting both income and reinvestment potential in drought-resistant technologies. In contrast, slightly larger farms may offer opportunities for crop rotation, intercropping, and improved soil management. The findings suggest that any drought resilience interventions such as input subsidies, extension support, or irrigation programs must consider farm size variations to ensure equitable and effective implementation.

4.1.6 How many years have you been engaged in maize farming?

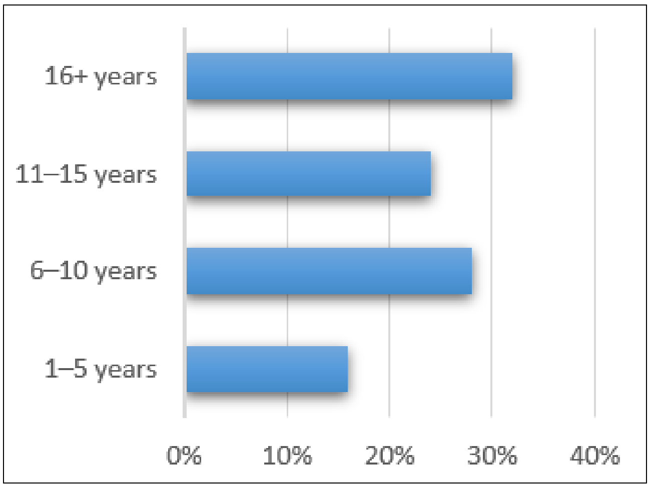

Fig 3: Respondents number of years in farming

The majority of respondents have been farming maize for a long time, with 32% having more than 16 years of experience and 24% between 11–15 years. This suggests that most farmers possess deep knowledge of local weather patterns, soil conditions, and farming practices. Only 16% are relatively new (1–5 years), which means the community has a strong base of experienced farmers who can lead adaptation practices. Therefore, it is evident that the effects of drought are being felt by both seasoned and new farmers, but long-term farmers may have more coping mechanisms based on experience. With these findings, the meaning is that training programs should build on existing indigenous knowledge while introducing modern techniques to enhance resilience.

4.2 Effects of Drought on Crop Viability

4.2.1 Average Maize Yield per Acre in a Normal Season

Table 3: Average Maize Yield per acre in normal season

Average Yield (kg/acre)	Frequency	Percentage (%)
Less than 500 kg	10	12.5%
500–800 kg	28	35%
801–1,200 kg	26	32.5%
1,201–1,500 kg	10	12.5%
Above 1,500 kg	6	7.5%
Total	**80**	**100%**

The data indicates that most farmers (35%) reported an average maize yield ranging between 500–800 kg per acre under normal rainfall conditions, while 32.5% achieved slightly higher yields of 801–1,200 kg. Only 7.5% of respondents recorded yields exceeding 1,500 kg per acre, suggesting that high productivity levels are rare among small-scale farmers in Munga Ward. These yields fall below Zambia's national average for commercial production, which typically exceeds 2,500 kg/acre, highlighting the productivity gap between smallholder and large-scale systems.

Therefore, it is evident that even under favorable conditions, small-scale farmers operate under yield constraints largely due to limited inputs, small landholdings, and reliance on rainfall. This establishes a baseline that helps quantify the severity of drought impacts. When normal yields are already low, subsequent drought shocks can push households into acute food insecurity. Thus, understanding pre-drought production levels is vital for assessing vulnerability and designing yield stabilization strategies.

4.2.2 How Does Drought Affect the Quality of Your Maize Crop?

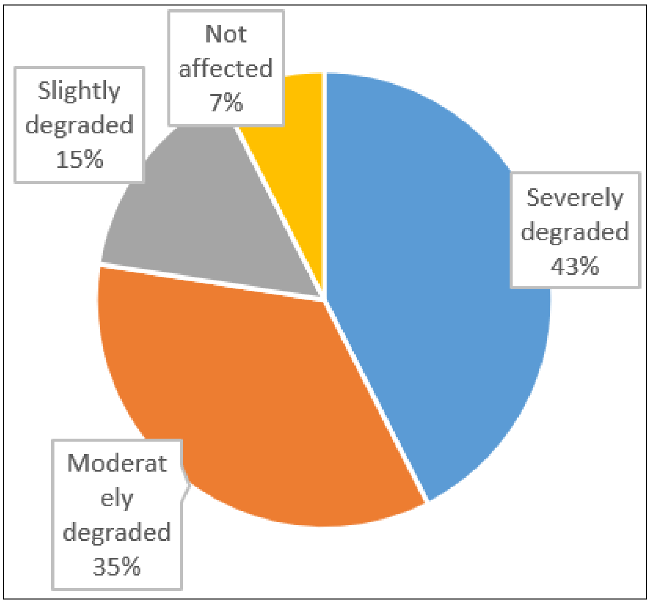

Fig 4: Effect of drought on the quality of maize crop

The results indicate that a majority of respondents (42.5%) experienced severe degradation of maize quality during drought periods, while 35% reported moderate degradation. This decline manifests through smaller grain size, shriveled kernels, and reduced starch content, making the produce less marketable and nutritionally inferior. Only 7.5% indicated that their crop quality was not affected, likely due to the use of improved or drought-tolerant varieties. Therefore, it is evident that drought not only reduces yield quantity but also compromises the quality of maize harvested. Degraded maize has lower caloric and protein value and is more prone to contamination by aflatoxins, posing both economic and health risks. With these findings, the meaning is that interventions must go beyond yield restoration to include post-harvest quality assurance and extension training on grain management under stress conditions.

4.2.3 Main Cause of Drought-Related Crop Losses in Your Area

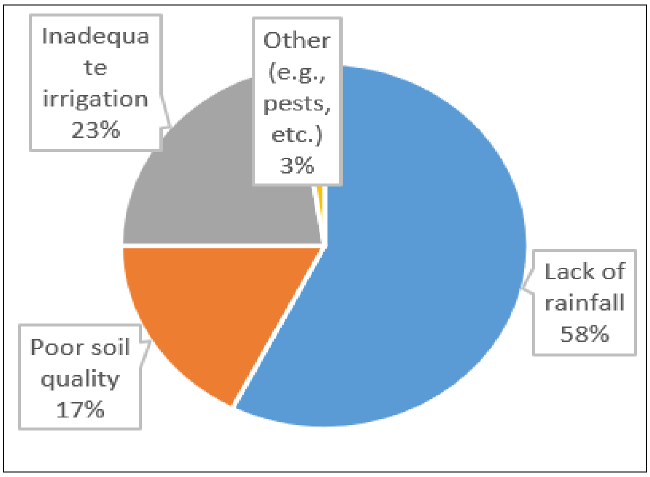

Fig 5: Main causes of drought related crop losses in your area

Over half (57.5%) of the farmers identified lack of rainfall as the main cause of drought-related crop losses, followed by inadequate irrigation (22.5%) and poor soil quality (17.5%). This reflects the rain-dependent nature of maize farming in Munga Ward, where very few farmers have access to reliable water sources or irrigation infrastructure. Additionally, degraded soils with low organic matter retention exacerbate drought stress by limiting moisture conservation and root growth.

Therefore, it is evident that climatic and infrastructural constraints jointly amplify drought impacts on maize viability. With these findings, the meaning is that improving water management practices, promoting soil fertility restoration, and expanding irrigation access are key steps toward drought resilience. Addressing these structural issues could significantly enhance.

4.3 Effects of Drought on Household Food Security.

4.3.1 How Does Drought Affect Your Household Food Availability?

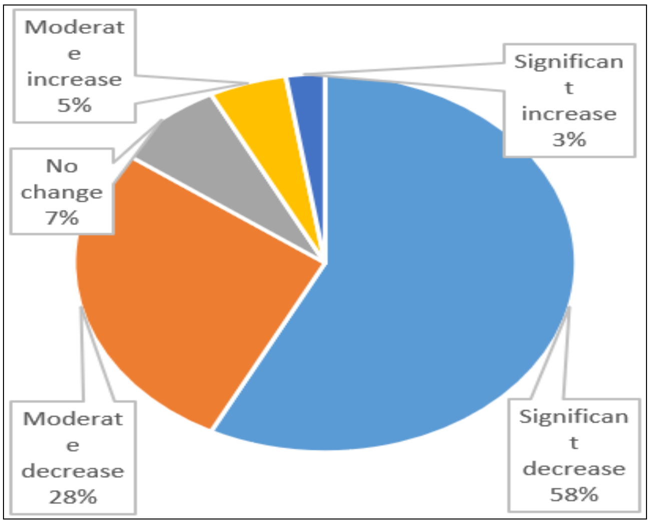

Fig 6: Effect of drought on household food availability

The results show that a majority of respondents (57.5%) experienced a significant decrease in food availability during drought periods, while 27.5% reported a moderate decrease. Only a marginal 7.5% indicated no change, implying that most households are heavily dependent on rainfall-dependent maize production for their food supply. When yields drop due to drought, household reserves diminish rapidly, leaving families vulnerable to hunger and food shortages.

Therefore, it is evident that drought exerts a direct and immediate impact on food availability in Munga Ward. As maize is both a staple and a key income source, crop failure directly translates into scarcity at household level. The findings demonstrate that drought undermines food self-sufficiency and forces reliance on market purchases, food aid, or coping mechanisms such as rationing. This confirms the central link between agricultural production and food access in smallholder communities.

4.3.2 For How Many Months in a Year Do You Struggle to Meet Household Food Needs Due to Drought?

Table 4: Struggle to meet Household food needs due to drought

Months of Food Shortage	Frequency	Percentage (%)
1–2 months	10	12.5%
3–5 months	32	40%
6–8 months	26	32.5%
9 months and above	12	15%
Total	**80**	**100%**

The majority of respondents (40%) reported struggling to meet household food needs for 3 to 5 months each year due to drought, while another 32.5% faced shortages lasting 6 to 8 months. Only 12.5% experienced brief shortages of one to two months. This reveals a concerning level of chronic food insecurity, where drought causes prolonged hunger and reliance on external assistance. Extended periods of food scarcity also strain household assets and increase debt levels, as families are forced to purchase food on credit or sell livestock to survive.

Therefore, it is evident that drought has transformed food insecurity from a seasonal issue into a persistent annual challenge in Munga Ward. With these findings, the meaning is that long drought spells disrupt production cycles and diminish household resilience. The prolonged shortage period highlights the need for sustainable drought adaptation strategies, such as grain storage systems, crop diversification, and food reserve programs to stabilize access during lean months.

4.3.3 Strategies Used to Cope with Food Shortages

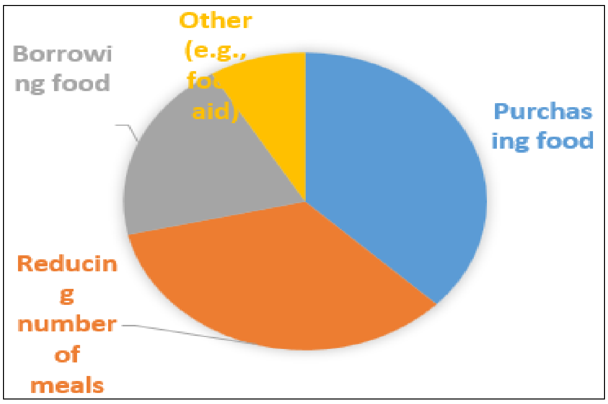

Fig 7: Strategies used to cope with food shortages

The data shows that purchasing food (65%) and reducing the number of meals (60%) are the two most common coping strategies adopted by farmers during drought-induced food shortages. About 35% reported borrowing food from relatives or neighbors, while 15% relied on food aid from government or church organizations. These strategies indicate that most households adopt reactive, short-term measures to manage food crises rather than long-term adaptive solutions.

Therefore, it is evident that the coping responses are primarily consumption-oriented, emphasizing survival rather than resilience. The reduction in meal frequency often leads to malnutrition, especially among children and pregnant women, while dependence on borrowing or food aid undermines self-reliance. With these findings, the meaning is that enhancing food storage capacity, promoting income diversification, and strengthening community safety nets are essential steps to improve long-term food stability during drought seasons.

4.3.4 How Does Drought Affect Your Household's Dietary Diversity?

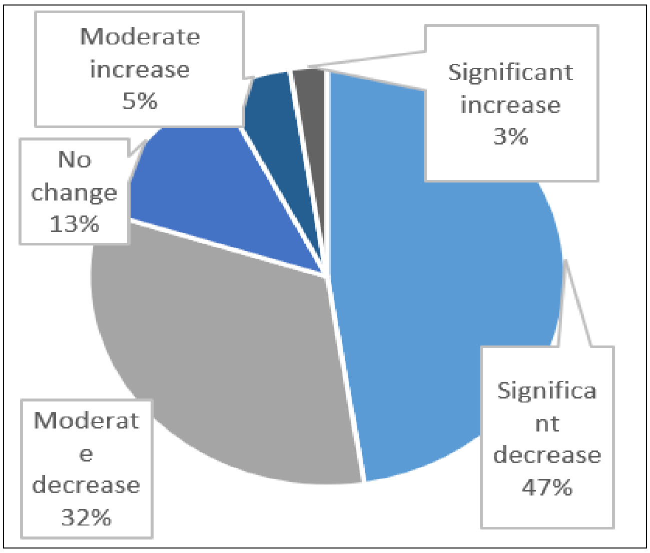

Fig 8: Effect of drought on household dietary diversity

Nearly half (47.5%) of respondents reported a significant decline in dietary diversity during droughts, while another 32.5% observed a moderate decrease. Only 12.5% maintained stable diets. This reduction in diversity means households depend primarily on maize-based meals and reduce the intake of nutritious foods such as legumes, vegetables, and animal products. Such dietary simplification leads to deficiencies in proteins, vitamins, and minerals, increasing the risk of malnutrition and disease.

4.3.5 Rate the Severity of Challenges in Maintaining Household Food Security during Drought

Table 5: Severity of challenges in maintaining household food security during drought

Challenge	Mean Rating (1–5)	Interpretation
High food prices	4.6	Very severe
Poor harvests/reduced yields	4.8	Very severe
Limited access to food markets	3.9	Severe
Lack of storage/preservation	4.2	Very severe

Respondents rated poor harvests (mean = 4.8) and high food prices (mean = 4.6) as the most severe challenges affecting food security during droughts. This reflects a double burden where production shocks reduce supply while price spikes limit affordability. Limited access to markets (mean = 3.9) and inadequate storage (mean = 4.2) further worsen food insecurity by restricting both physical and temporal availability of food. These findings align with national trends, where drought events trigger inflation in staple prices, particularly maize meal.

Therefore, it is evident that household food insecurity in Munga Ward is driven by both production and market failures. With these findings, the meaning is that interventions should not only focus on crop yields but also on stabilizing food prices and improving infrastructure. Establishing grain storage facilities, subsidized food depots, and market linkages during drought periods could buffer rural households against extreme shortages and price shocks.

4.4 Adaptation Strategies Employed by Small-Scale Maize Farmers

4.4.1 Which Strategies Do You Use to Reduce Drought Impact on Maize?

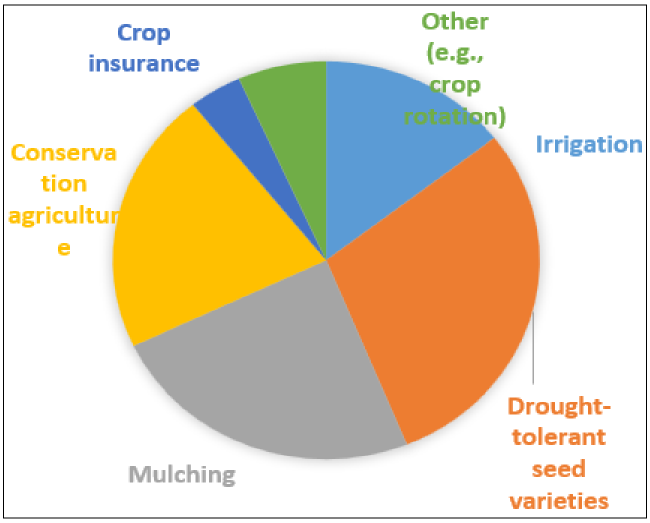

Fig 9: Which Strategies Do You Use to Reduce Drought Impact on Maize

The results reveal that the most common adaptation strategies are the use of drought-tolerant seed varieties (55%), mulching (45%), and conservation agriculture (40%). Fewer farmers (27.5%) practice irrigation due to limited access to water sources and equipment, while only 7.5% have adopted crop insurance schemes. The findings highlight that farmers are increasingly aware of and employing low-cost, sustainable methods to mitigate drought risks, particularly those that conserve soil moisture and improve resilience.

Therefore, it is evident that small-scale farmers rely mainly on affordable, traditional, and accessible techniques rather than capital-intensive innovations. The low uptake of irrigation and crop insurance reflects structural limitations such as inadequate infrastructure, financial barriers, and limited institutional support. With these findings, the meaning is that increasing awareness, expanding input subsidies, and improving access to credit could enhance the adoption and effectiveness of modern drought adaptation measures.

4.4.2 Rate the Effectiveness of These Strategies in Reducing Drought Impact

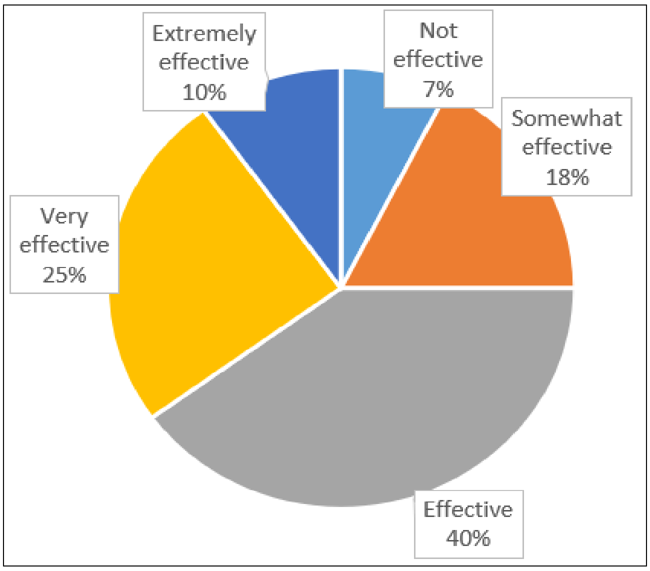

Fig 10: Ratings of the effectiveness of the strategies in reducing drought impact

Most respondents (40%) rated their drought adaptation strategies as effective, while another 25% considered them very effective. A smaller portion (17.5%) reported that their measures were only somewhat effective, suggesting variation in outcomes based on resource access and implementation levels. Farmers who used drought-tolerant seeds and mulching observed more consistent yields compared to those who relied solely on traditional practices.

Therefore, it is evident that most existing adaptation strategies deliver moderate success but remain limited by scale and technical support. With these findings, the meaning is that while farmers have developed coping mechanisms, their potential impact could be amplified through training, monitoring, and access to modern technologies. The perceived effectiveness shows promise, but sustained government and NGO interventions are crucial to transform these localized efforts into long-term resilience systems.

4.4.3 Rate the Severity of the Following Challenges in Implementing Drought Adaptation Strategies

Table 6: Severity of the following challenges in implementing drought strategies

Challenge	Mean Rating (1–5)	Interpretation
Lack of financial resources	4.7	Very serious challenge
Limited knowledge or training	4.3	Very serious challenge
Poor access to inputs	4.5	Very serious challenge
Inadequate support from extension services	4.1	Serious challenge

The data indicates that lack of financial resources (mean = 4.7) and poor access to inputs (mean = 4.5) are the most severe challenges farmers face in implementing adaptation strategies. Limited training and inadequate extension support also emerged as serious barriers, with mean scores above 4.0. These findings confirm that while farmers are willing to adapt, structural and financial limitations prevent them from fully adopting modern technologies or scaling effective practices.

Therefore, it is evident that adaptation barriers are more institutional than behavioral. Farmers possess experiential knowledge and willingness but lack the means to act on it effectively. With these findings, the meaning is that enhancing agricultural financing, improving supply chains for inputs, and strengthening extension outreach are essential to enable full-scale adoption of drought-resilient strategies.

4.4.4 How Do You Access Information on Adaptation Strategies?

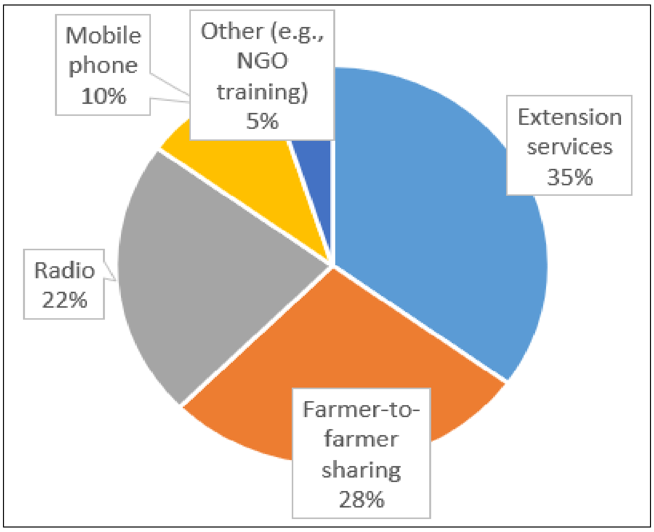

Fig 11: Access of information on adaptation strategies

The majority of farmers (35%) reported that they access information on drought adaptation primarily through extension services, followed by peer learning (27.5%) and radio programs (22.5%). This suggests that interpersonal and mass communication channels remain vital in disseminating agricultural knowledge. However, the relatively low use of mobile phones (10%) and NGO channels (5%) indicates limited digital penetration and outreach by development partners in Munga Ward.

Therefore, it is evident that extension officers play a crucial role in bridging the knowledge gap between farmers and scientific innovation. With these findings, the meaning is that enhancing extension capacity and integrating modern ICT tools, such as mobile apps and SMS-based alerts, can improve knowledge dissemination. Strengthening farmer-to-farmer platforms would also ensure continuous learning and adaptation across communities.

4.4.5 What Additional Support Would Improve Your Ability to Adapt to Drought?

Table 7: Additional support to improve adaption strategies

Support Type	Frequency (Multiple Responses)	Percentage (%)
Access to affordable inputs	52	65%
Training on climate-smart farming	46	57.5%
Access to credit	38	47.5%
Government subsidies	34	42.5%
Other (e.g., irrigation schemes)	10	12.5%

The most frequently cited support needs were access to affordable inputs (65%), training on climate-smart agriculture (57.5%), and access to credit (47.5%). These priorities reflect farmers' recognition that resilience depends on both knowledge and resources. Government subsidies (42.5%) were also emphasized, highlighting the role of public support in offsetting high production costs. A few respondents (12.5%) also mentioned irrigation development as a necessary intervention.

Therefore, it is evident that effective drought adaptation requires a multifaceted support system. With these findings, the meaning is that resource access, financial inclusion, and targeted training should form the foundation of policy responses. Integrating these elements can empower farmers not only to cope with drought but to transform their agricultural systems into more resilient and sustainable enterprises.

4.4.6 How Should the Government or Stakeholders Support Small-Scale Maize Farmers in Adapting to Drought?

Sample Farmer Responses:

1. *"Government should introduce irrigation schemes and boreholes so that we can plant even when there is no rain."*
2. *"There is need for more training on climate-smart farming and timely delivery of farming inputs."*
3. *"Access to soft loans or credit would help us buy drought-resistant seeds and fertilizers."*
4. *"Extension officers should visit us more frequently to guide us on new farming techniques."*
5. *"The government and NGOs should provide subsidies and promote insurance for small farmers against drought losses."*

The open-ended responses emphasize that farmers view infrastructure, capacity building, and financial access as the most pressing areas for support. The frequent mention of irrigation and training reflects a desire for long-term adaptation mechanisms rather than short-term relief. Farmers also underscored the importance of continuous engagement with extension services and improved access to credit facilities for purchasing inputs.

Therefore, it is evident that small-scale farmers understand the multifaceted nature of drought resilience and seek both institutional and technological solutions. With these findings, the meaning is that effective policy interventions must integrate physical infrastructure (like irrigation), capacity development, and economic empowerment. Strengthening coordination between government, NGOs, and local cooperatives will be essential in transforming these recommendations into practical, sustainable outcomes.

4.5 Discussion of Results

This section integrates quantitative and qualitative findings to provide a holistic understanding of drought impacts on maize production among small-scale farmers in Munga Ward, Kabwe District. Statistical results from questionnaires were triangulated with interview insights, strengthening the reliability of interpretations across three major themes: effects on crop viability, household food security, and adaptation strategies.

Theme 1: Effects of Drought on Crop Viability

Quantitative data showed that 52.5% of farmers experienced significant yield declines over the past five years, while 30% reported moderate losses. The tasseling (32.5%) and silking (30%) stages were identified as most drought-sensitive, with average yield reductions of 40–60%. Additionally, 42.5% observed quality deterioration through shriveled grains and smaller kernels.

Qualitative data reinforced these trends, with farmers describing drought as a "constant threat" that shortens growing seasons and disrupts planting calendars. One participant stated, "Even if we plant early, the rain disappears when maize needs it most." Poor soil moisture and high temperatures were noted as major contributors to frequent replanting and poor germination. Both datasets confirm that drought undermines maize's physiological viability and farmers' economic sustainability, highlighting the need for drought-tolerant seeds, soil conservation, and irrigation support.

Theme 2: Effects of Drought on Household Food Security

Over half of the respondents (57.5%) reported food shortages lasting 3–5 months annually, while 47.5% experienced reduced dietary diversity and 55% observed deteriorating nutrition. Common coping mechanisms included food purchases (65%), meal reduction (60%), and borrowing food (35%).

Interview findings humanized these statistics, with farmers narrating skipped meals and reduced nutrition. One woman stated, "Sometimes we eat only once a day, just nshima without relish." Rising maize prices further deepened food insecurity, transforming producers into dependent consumers. The synthesis underscores that drought impacts extend beyond yields, affecting economic and nutritional well-being. Building resilience thus requires interventions addressing market stability, income diversification, and nutrition education.

Theme 3: Adaptation Strategies among Small-Scale Farmers

Quantitatively, 55% of farmers adopted drought-tolerant seeds, 45% practiced mulching, and 40% used conservation agriculture. Yet financial constraints (mean = 4.7), limited inputs (4.5), and weak extension services (4.1) hindered effectiveness.

Qualitative evidence revealed that awareness outpaces implementation. One farmer noted, "We know about conservation farming, but without fertilizer and tools, it's hard." Participants emphasized the need for credit access, climate-smart training, and irrigation support.

Overall, the synthesis shows that drought is both an environmental and socio-economic challenge eroding natural, financial, and social assets. Sustainable solutions require integrating technical interventions with institutional support, linking research, policy, and farmer participation to strengthen resilience in Zambia's drought-prone regions.

5. Conclusion

The study assessed the effects of drought on maize production among small-scale farmers in Munga Ward, Kabwe District, focusing on crop viability, household food security, and adaptation strategies. Using a mixed-method approach under the Sustainable Livelihoods Framework, the research combined quantitative and qualitative data to capture the multidimensional effects of drought.

Findings revealed that over 52% of farmer's experienced severe yield declines of 40–60% in the past five years, with tasseling and silking identified as the most drought-sensitive stages. Poor soil moisture and lack of irrigation further reduced crop viability and quality.

Drought also undermined household food security, with 57% of respondents facing shortages lasting three to five months yearly. Rising food prices, reduced access to markets, and decreased meal frequency led to poor dietary diversity and malnutrition, particularly among children and women.

Adaptation strategies such as drought-tolerant seeds (55%), mulching (45%), and conservation agriculture (40%) were adopted but constrained by limited finances, inputs, and extension support. While farmers showed willingness to adapt, inadequate institutional capacity hindered effectiveness.

Overall, drought threatens both maize viability and livelihood stability. Strengthening extension services, improving access to inputs and credit, and expanding irrigation infrastructure are crucial for enhancing drought resilience and food security in Munga Ward.

6. Acknowledgement

I would like to express my greatest gratitude to Information and Communications University Lecturers and fellow students who supported me in my study journey and final year research project. I also would Love to express my deepest gratitude to family and friends for their assistance both morally and mentally and to all of those who supported me in the completion of this thesis for their endless support, God bless them.

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