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Examining the Effect of Drought on Maize Production: A Case Study on Small-Scale Farmers in Ibenga Ward

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Abstract

This study examined the effects of drought on maize production among small-scale farmers in Ibenga Ward, motivated by growing concern that recurrent dry spells continue to undermine Zambia's rural food systems despite national climate adaptation efforts. The problem statement highlighted widening vulnerability among small-scale farmers who depend on rain-fed production and lack adequate access to drought-tolerant seed, irrigation infrastructure, and institutional support. The study was guided by three objectives: Assessing the effects of drought on maize yields among small-scale farmers, analyzing the coping strategies used to mitigate drought impacts, and evaluating how declining maize yields affect household food security. A case study design anchored in the Climate-Smart Agriculture framework was used to capture both quantitative and qualitative dimensions of drought impacts. The sample comprised 80 household farmers, 15 FGD participants, and 5 key informants selected through purposive sampling. Data were collected using structured questionnaires, focus group discussions, and key informant interviews, while quantitative data were analyzed using descriptive statistics and chi-square tests, and qualitative data were examined thematically. The findings revealed a substantial decline in maize yields during drought years, with 45.0% of farmers harvesting only 5–10 bags in the 2023/2024 drought season compared to 42.5% who harvested 10–20 bags during normal rainfall years. Furthermore, 47.5% experienced yield reductions of 11–20 bags, while 30.0% reported that the tasseling stage was the most drought-sensitive. Regarding coping strategies, 60.0% of farmers adopted drought-tolerant seed varieties, while early planting (32.5%), crop diversification (22.5%), conservation tillage (20.0%), and mulching (17.5%) were also commonly used. However, 55.0% of farmers still relied exclusively on rain-fed production, and 40.0% received no institutional support during the previous farming season, demonstrating significant gaps in adaptation capacity. The effects of drought on food security were equally severe, with 57.5% of households reducing meal frequency to two meals per day, 27.5% surviving on one meal, and 42.5% experiencing only 4–6 months of adequate food provisioning. Additionally, 40.0% of households reduced maize consumption by half, while 32.5% reported meal skipping by both adults and children. The study concludes that drought in Ibenga Ward has produced interlinked challenges declining maize yields, constrained coping capacity, and worsening household food insecurity exacerbated by limited institutional support and dependence on rain-fed agriculture. It further recommends strengthening access to drought-tolerant seeds and small-scale irrigation, expanding agricultural extension services, improving institutional coordination, establishing community grain reserves, and promoting livelihood diversification to enhance resilience and food security.

Keywords: Drought, Maize Production, Small-Scale Farmers, Food Security, Climate-Smart Agriculture, Coping Strategies, Ibenga Ward

1. Introduction

1.1 Background

Drought is a recurring climatic hazard characterized by prolonged periods of below-average rainfall, leading to soil moisture deficits that negatively affect crop growth and food production (UNCCD, 2022) [20]. Globally, drought has intensified due to climate change, posing major threats to food systems and rural livelihoods. According to the Food and Agriculture Organization (FAO, 2023), more than 55 million people are affected by drought annually, with maize production the world's

most widely cultivated cereal particularly vulnerable due to its high water demand. Recent projections indicate that global maize yields may decline by 24% by 2050 if current temperature and rainfall trends persist (Liu *et al*., 2021). Countries across Asia, the Americas, and Europe have invested heavily in climate-smart agriculture, drought-resistant crop varieties, and irrigation technologies to mitigate these risks (Shiferaw *et al*., 2019).

Across Sub-Saharan Africa, drought remains the most severe natural hazard, affecting over 45% of cultivated land and reducing cereal production by up to 40% during severe episodes (World Bank, 2021). The region's high dependence on rain-fed agriculture makes smallholder farmers particularly vulnerable to rainfall variability. Studies in Ethiopia, Kenya, and Malawi have shown that prolonged dry spells result in widespread crop failure, food insecurity, and rural poverty (Mekonnen *et al*., 2020; Ayanlade *et al*., 2018). Despite the adoption of coping strategies such as intercropping, conservation agriculture, and water harvesting, farmers continue to experience yield losses due to limited access to irrigation facilities, credit, and climate information (Nhemachena *et al*., 2020). Maize, which is both a staple food and an income source for most smallholders, has been most severely affected, contributing to rising household food insecurity across the region (Gebrechorkos *et al*., 2019) [6].

In Zambia, agriculture remains the backbone of rural livelihoods, engaging over 70% of the population, with maize being the dominant staple crop (ZamStats, 2023). However, the increasing frequency and intensity of droughts have significantly undermined production, especially in drought-prone regions such as Southern, Central, and Copperbelt Provinces (Mulenga *et al*., 2020). The Zambia Meteorological Department (2023) [21] reported that between 2018 and 2023, maize yields declined by an average of 35% in affected districts. Ibenga Ward, located in Mpongwe District, experiences recurrent dry spells that disrupt planting and harvesting cycles, causing food shortages and income instability among small-scale farmers. Despite government interventions such as the Farmer Input Support Programme (FISP) and the National Policy on Climate Change, the persistence of drought-related yield losses suggests that local-level adaptation remains weak (Phiri & Simukoko, 2019) [16]. This study, therefore, focuses on examining the effects of drought on maize yields, the coping strategies employed by smallholders, and the broader implications for food security in Ibenga Ward.

1.2 Statement of the Problem

Despite national and international efforts to enhance climate resilience, drought continues to pose a critical challenge to Zambia's agricultural productivity, particularly among small-scale maize farmers who depend almost entirely on rainfall for cultivation. National crop forecast surveys have consistently shown significant yield reductions during drought years, with the 2022/2023 farming season reporting maize losses exceeding 30% across several districts in Copperbelt and Central Provinces (Ministry of Agriculture, 2023) [10]. In Ibenga Ward, erratic rainfall patterns and prolonged dry spells have led to repeated crop failures, undermining household food security and rural livelihoods. Although climate adaptation policies advocate for the use of drought-tolerant seed, irrigation, and early warning systems, most small-scale farmers remain unable to adopt these measures due to limited access to inputs, finance, and extension services. Empirical evidence highlights that rural adaptation capacity remains low, with most farmers still relying on traditional coping mechanisms that provide only short-term relief (Banda & Tembo, 2021) [3]. This disconnect between national policy commitments and local realities has widened the vulnerability of farming households to drought-related shocks. Therefore, this study aims to examine the extent of drought's impact on maize yields, analyze the coping strategies adopted by small-scale farmers, and evaluate the effects of reduced yields on household food security in Ibenga Ward.

1.3 Objective

1.3.1 General Objective

The main objective of this study is to examine the effect of drought on maize production among small-scale farmers in Ibenga Ward.

1.3.2 Specific Objectives

1. To assess the effects of drought on maize yields among small-scale farmers in Ibenga Ward.
2. To analyze the key coping strategies used by small-scale farmers in Ibenga to mitigate the effects of drought.
3. To evaluate the effects of low maize yields on food security among small-scale farmers in Ibenga Ward.

1.4 Research Questions

1. What are the effects of drought on maize yields among small-scale farmers in Ibenga Ward?
2. Which coping strategies are being employed by small-scale farmers in Ibenga to mitigate the effects of drought?
3. How have low maize yields affected household food security among small-scale farmers in Ibenga Ward?

1.5 Theoretical Framework

The theoretical framework guiding this study is the Climate-Smart Agriculture (CSA) framework, which has gained prominence in recent years as a response to the challenges posed by climate change, particularly in developing countries like Zambia. Climate-Smart Agriculture integrates the principles of sustainable agricultural practices with adaptive strategies to enhance resilience against climate variability and change. The framework is built on three core pillars: Increasing agricultural productivity, enhancing resilience to climate change, and reducing greenhouse gas emissions where possible (FAO, 2015) [5]. These principles make CSA particularly relevant for investigating the impact of drought on small-scale farming systems in Ibenga Ward. The Climate-Smart Agriculture framework offers a reliable foundation for understanding how farmers adapt to drought and its associated challenges, such as reduced crop yields and food insecurity. According to the framework, enhancing the adaptive capacity of farmers requires not only technological innovations like drought-tolerant crops and improved irrigation systems, but also institutional support, policy frameworks, and the active involvement of local communities (Thornton *et al*., 2018) [19].

2. Literature Review

2.1 The Effects of Drought on Maize Yields Among Small-Scale Farmers

Globally, drought remains the most damaging climatic

constraint to maize production, responsible for nearly 60 percent of yield losses in rain-fed systems (FAO, 2021). Lobell *et al*. (2015), analysing a thirty-year dataset from major United States maize-producing states, found that a one-degree Celsius rise during drought years reduced yields by 17 percent, demonstrating maize's sensitivity to heat-induced moisture stress. Similarly, Zhang *et al*. (2021) [23] simulated drought scenarios in China's northern plains and reported 25 to 45 percent yield declines depending on drought timing, with early-season events reducing plant establishment and late-season drought constraining grain filling. A global meta-analysis by Lesk *et al*. (2016) [8] further demonstrated that maize experiences an average 9.4 percent yield loss during drought years, the highest among major cereals. More recently, Kim *et al*. (2023) showed that drought-tolerant genotypes expressing ZmDREB2A and ZmNAC111 retained 30 percent more biomass, highlighting the potential of molecular breeding while noting gaps in accessibility for smallholder farmers.

Across Sub-Saharan Africa, where over 90 percent of agriculture is rain-fed, drought frequently causes maize yield declines ranging between 30 and 60 percent. Makate *et al*. (2017), studying Zimbabwe and Malawi, documented a 45 percent drop in drought years, moderated to 28 percent among farmers with access to hybrid seed and credit. In Kenya, Kogo *et al*. (2020) identified a strong negative correlation between rainfall deficits and yields ($r = –0.73$), with severe droughts reducing productivity by 52 percent, though soil-moisture conservation limited losses by 15 percent. In Ethiopia, Mekonnen *et al*. (2021) found that a one-percent decline in seasonal rainfall lowered yields by 0.65 percent, while farms with supplementary irrigation saw only 12 percent reductions compared to 38 percent in fully rain-fed fields. In Uganda, Okonya *et al*. (2019) established that recurrent drought caused 41 percent annual yield losses but that access to drought-tolerant seed increased yields by 28 percent, demonstrating the effectiveness of targeted adaptation interventions.

In Zambia, maize is the country's primary staple and the crop most sensitive to seasonal rainfall variability. Studies consistently show substantial yield reductions during drought years, especially among small-scale farmers dependent on rain-fed systems. Munalula *et al*. (2018), examining Central and Southern Provinces, found that prolonged mid-season dry spells reduced maize yields by 35 to 40 percent, exacerbated by limited access to irrigation and fertilizer. Sinkala and Nkonde (2020) reported that farmers in agro-ecological zones I and II experienced up to 50 percent yield decline during the 2018–2019 drought, with households cultivating less than two hectares being the most affected. Chisanga *et al*. (2021) highlighted that despite government promotion of early-maturing varieties, adoption gaps remained, contributing to 30 percent lower yields among non-adopters during drought years. A recent assessment by Zulu and Phiri (2023) in Copperbelt Province showed yields falling from 2.8 tons per hectare to 1.4 tons in drought conditions, while farmers with basic water-harvesting techniques experienced only 25 percent reductions. Collectively, Zambian evidence shows that drought strongly undermines maize production due to inadequate water management, limited access to stress-tolerant varieties, and inconsistent extension services. These constraints mirror broader regional challenges but manifest more acutely where smallholders rely almost entirely on rainfall, as is the case for farmers in Ibenga Ward.

2.2 Key coping strategies used by small-scale farmers in Ibenga to mitigate the effects of drought

Globally, small-scale farmers have adopted various coping mechanisms to withstand the impacts of drought as climate change intensifies rainfall variability. These strategies generally include drought-tolerant crop varieties, shifting planting dates, water harvesting, income diversification, and early warning systems. Nguyen *et al*. (2019) [13] found that rice farmers in Vietnam increasingly relied on short-maturing seed varieties and reduced cultivation area to manage water scarcity, although yield losses persisted without irrigation access. Similarly, Sharma and Singh (2020) [17] observed that Indian farmers applied strategies such as intercropping, livestock selling, and migration, with the choice of responses dependent on resource availability. Overall, global evidence highlights disparities where wealthier farmers utilize productive coping while poorer farmers adopt distress measures, deepening long-term vulnerability to drought shocks.

In Sub-Saharan Africa, coping strategies remain vital because agriculture is predominantly rain-fed. A study in Kenya by Muriuki *et al*. (2019) [12] revealed the use of traditional moisture conservation techniques such as zai pits and staggered planting, combined with emergency actions such as livestock sales during prolonged drought. Agyeman *et al*. (2020) [2] reported that livelihood diversification into petty trade or wage labor significantly improved drought recovery in Ghana, although poorer households faced limited diversification opportunities. In Ethiopia, Mekuria and Gebru (2022) [9] found that informal systems including grain loans and communal labor groups strengthened short-term resilience. Abdoulaye *et al*. (2021) [1] documented the use of water harvesting structures in Niger, which improved yields but required collective labor investment. Evidence across the region shows that while innovation is occurring, limited access to credit, extension services, and climate information constrains effective adaptation.

In Zambia, smallholder coping strategies reflect a mix of traditional practices and external interventions. Tembo and Chola (2018) [18] found that food rationing, informal borrowing, and crop diversification into cassava and sorghum were common responses to erratic rainfall, but these could lead to long-term asset depletion. Phiri and Simukoko (2019) [16] demonstrated that early-maturing seed distributed through the Farmer Input Support Programme reduced food insecurity during drought, although access remained unequal and delivery timing inconsistent. Banda and Tembo (2021) [3] emphasized the continued importance of indigenous practices such as seed preservation and communal labor sharing; however, they warned these approaches are threatened by declining social cohesion. Recent evidence from Mulenga and Chanda (2018) [11] showed that mobile-based weather information improved planting decisions among farmers with digital access. In Ibenga specifically, Kalinda and Mweemba (2019) [7] reported reliance on livestock sales, reduced meal frequency, casual labor, and informal seed exchange during recent drought years. Collectively, these findings indicate that coping in Zambia remains largely reactive and constrained by limited institutional support, suggesting the need for more transformative adaptation strategies such as small-scale irrigation, strengthened extension services, and

improved access to financial services.

2.3 The Effects of Low Maize Yields on Food Security Among Small-Scale Farmers

Globally, declining maize yields continue to threaten food security, particularly among populations dependent on maize for energy intake. Lobell *et al*. (2015) demonstrated that global maize yields fall by roughly 10 percent for every one-degree Celsius rise in temperature, with drought explaining almost 60 percent of total yield variation. Similar findings were reported in the United States where Tack *et al*. (2017) showed that a 20 percent yield reduction during the 2012 drought resulted in a 14 percent rise in retail maize prices, reducing affordability for low-income households. In Latin America, Ramirez-Villegas *et al*. (2018) found that droughts caused average yield losses of 36 percent and reduced household calorie consumption by 22 percent. Complementing these studies, Cohn *et al*. (2020) estimated that drought-related maize losses contributed to an additional 12 million undernourished people annually across 82 developing countries. Collectively, global literature confirms that reduced maize yields undermine food availability, dietary diversity, and income stability.

Across Sub-Saharan Africa, maize provides up to 40 percent of daily caloric intake (FAO, 2021), making drought-related yield declines a major food security threat. In Ethiopia, Wossen *et al*. (2017) found that a 10 percent yield decline increased household food insecurity probability by 6 percent. Malawi recorded national output reductions of up to 45 percent during El Niño years, which Fisher *et al*. (2015) linked directly to higher hunger levels. Kenya faced similar effects, as Makate *et al*. (2019) reported that households losing 30 percent or more of their maize harvest registered 50 percent lower dietary diversity scores. In Zimbabwe, Muchomba *et al*. (2020) found that recurrent droughts reduced yields by 38 percent and decreased food consumption scores by 22 percent. Regional evidence highlights that limited irrigation, dependence on rain-fed systems, and weak institutional support intensify the food security impacts of declining maize yields.

In Zambia, maize accounts for over 60 percent of national caloric intake and more than 80 percent of cultivated land (Ministry of Agriculture, 2023) [10]. Recent droughts have severely constrained production, with the Food Reserve Agency reporting a 30 percent decline in the 2022/2023 season in drought-affected provinces. Mwape and Kalinda (2019) showed that households experiencing yield reductions of 25 percent or more recorded 41 percent lower dietary diversity scores. Similarly, Chisanga and Chapoto (2020) found that a 30 percent drop in maize output increased household food expenditure by 18 percent due to reliance on purchased foods. In Southern Province, Nkomoki *et al*. (2021) demonstrated that maize yield losses exceeding 20 percent significantly heightened Household Food Insecurity Access Scale scores. Further, Musonda *et al*. (2022) observed that yield declines pushed households toward coping strategies such as meal reduction and increased dependence on food aid. Overall, Zambian evidence shows that low maize yields directly weaken food availability, affordability, and nutritional adequacy, placing small-scale farmers at heightened risk of chronic food insecurity.

2.4 Establishment of Research Gap

Despite extensive global and regional research on drought and its implications for smallholder agriculture, critical gaps persist in understanding the specific interactions between drought intensity, maize yield variability, and food security outcomes within localized Zambian contexts such as Ibenga Ward. Most existing studies have generalized findings across regions without adequately considering micro-climatic variations, soil diversity, and socio-economic disparities among households. Additionally, while many works document coping strategies, few have examined how these strategies influence long-term resilience or sustainability of maize production. There is also a paucity of empirical evidence linking declining maize yields directly to household food security, particularly in relation to nutrition adequacy, dietary diversity, and intra-household food allocation. Furthermore, the integration of local indigenous knowledge systems with modern climate adaptation frameworks remains largely unexplored. This study therefore bridges these gaps by contextualizing the effects of drought on maize yields and household food security, focusing on locally grounded evidence that informs targeted interventions for small-scale farmers in Ibenga Ward.

3. Research Methodology

3.1 Research Design

A case study research design was used to provide an in-depth analysis of how drought affected maize production among small-scale farmers in Ibenga Ward. This design was considered suitable because drought impacts were highly contextual and shaped by local environmental and socio-economic conditions that needed to be examined within their real-world setting (Yin, 2018). It enabled a detailed understanding of farmers' experiences, production constraints, and coping strategies. The design also supported multiple data collection methods such as questionnaires, focus group discussions, and key informant interviews, enhancing triangulation and strengthening contextual interpretation (Crowe *et al*., 2019).

3.2 Target Population

The target population consisted of approximately 1,000 small-scale farmers in Ibenga Ward who depended mainly on rain-fed agriculture for their livelihood security (Ministry of Agriculture, 2023) [10]. These farmers primarily cultivated maize, cassava, and groundnuts, making them susceptible to rainfall shortages and prolonged dry spells (Mulenga *et al*., 2020). Ibenga had repeatedly experienced drought-related crop failure, reduced harvests, and declining soil moisture in recent years (ZamStats, 2021). This population was appropriate because their lived experiences provided critical insight into how recurrent drought affected farming systems and household food availability in rural Zambia.

3.3 Sampling Design and Sample Size

A purposive sampling approach was used to select farmers with at least three farming seasons in Ibenga and direct experience of drought impacts, ensuring relevance and knowledge of climate-related challenges (Etikan and Bala, 2017). The study involved 80 household farmers, 15 focus group participants, and 5 key informants, giving a total of 100 respondents. The farmer sample was determined using

Yamane's (1967) formula: n = 1000 / (1 + 1000(0.095²)) = 100. Key informants included agricultural officers, cooperative leaders, and local authorities, enhancing credibility and diversity (Palinkas *et al*., 2015) [14].

3.4 Data Collection Methods

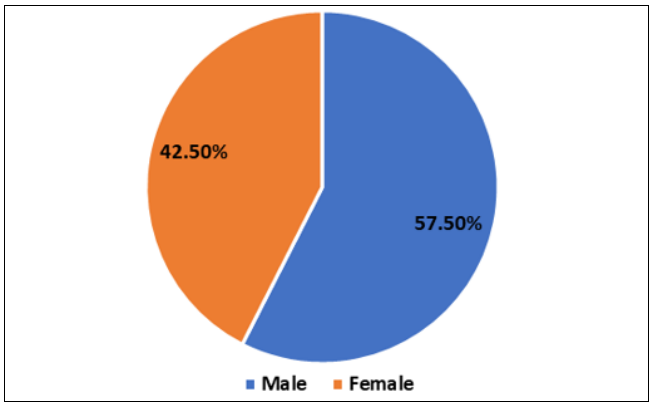
Data were gathered through structured questionnaires, focus group discussions, and key informant interviews. The questionnaires collected quantitative data on maize yields, drought frequency, farming practices, and household food security using closed-ended and Likert-scale questions to ensure accuracy (FAO, 2020). The focus group discussions explored shared drought experiences, community-level responses, and changes in food availability. Key informant interviews captured expert perspectives on drought management and institutional support mechanisms. Semi-structured guides ensured consistency across interviews while allowing probing (Bryman, 2016). This combination enriched the dataset through integrated numerical and narrative evidence.

3.5 Data Analysis

Quantitative data were analyzed using descriptive statistics including frequencies, percentages, and mean scores to examine variations in crop yields, drought severity, and food security outcomes. Chi-square tests were used to identify associations between drought intensity and household food security indicators using SPSS software (Pallant, 2020) [15]. Qualitative data from focus groups and interviews underwent thematic analysis guided by Braun and Clarke's (2019) [4] six-phase approach, including coding and theme development. Results were presented through tables, charts, and narrative summaries. Integrating statistical and thematic evidence enhanced methodological rigor and deepened understanding of drought impacts in Ibenga Ward.

4. Findings and Results

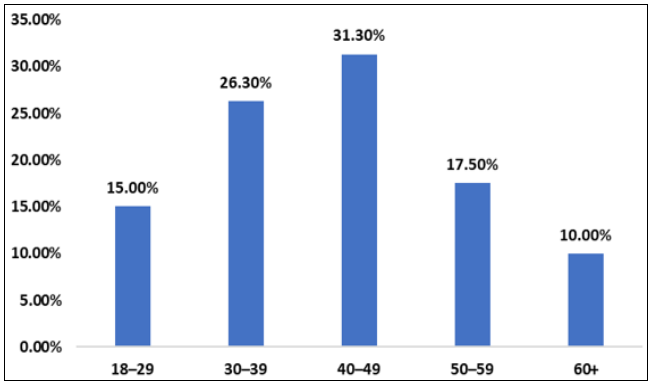
4.1 Background Characteristics of Respondents



Source: Primary Data, 2025

Fig 1: Sex of Respondents

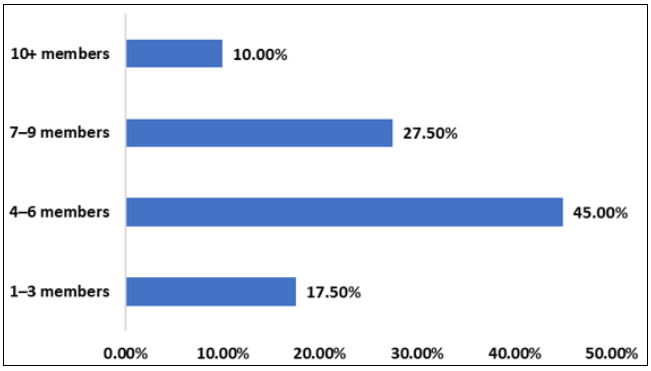
Fig 1 shows that 46 respondents (57.5%) were male, while 34 (42.5%) were female.



Source: Primary Data, 2025

Fig 2: Age Groups

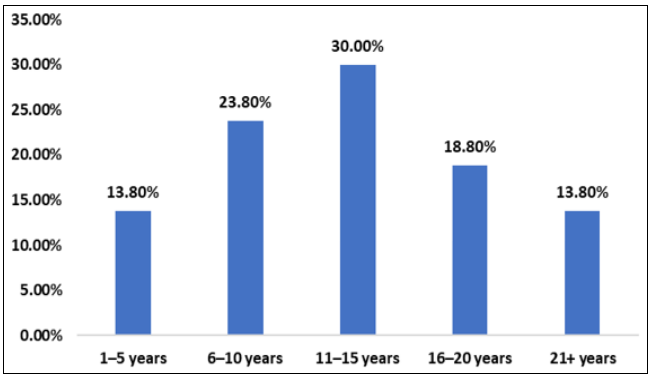
Fig 2 shows that the largest proportion of respondents were aged 40–49 years (31.3%), followed by those aged 30–39 years (26.3%) and 18–29 years (15%). Those aged 50–59 accounted for 17.5%, while respondents aged 60 and above represented 10%.



Source: Primary Data, 2025

Fig 3: Household Size

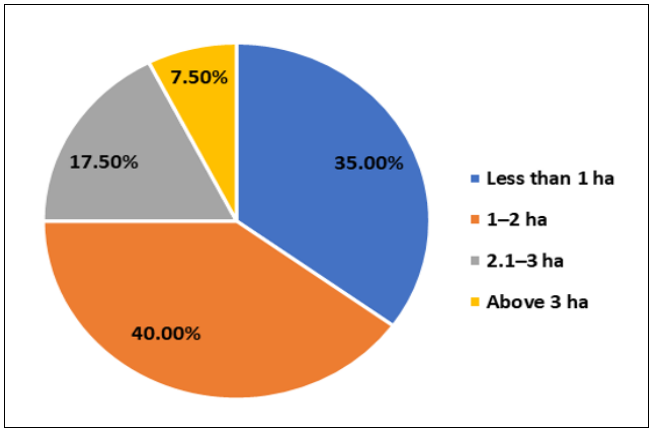
Findings in Fig 3 show that most respondents (45.0%) lived in households with 4-6 members, followed by those in households of 7-9 members (27.5%). Smaller households of 1-3 members accounted for 17.5%, while 10% belonged to households with 10 or more members.



Source: Primary Data, 2025

Fig 4: Farming Experience

Fig 4 shows that most respondents had 11-15 years of farming experience, represented by 24 farmers (30.0%). This was followed by 19 farmers (23.8%) with 6-10 years and 15 farmers (18.8%) with 16-20 years of experience. Those with 1-5 years and 21+ years each accounted for 11 farmers (13.8%).

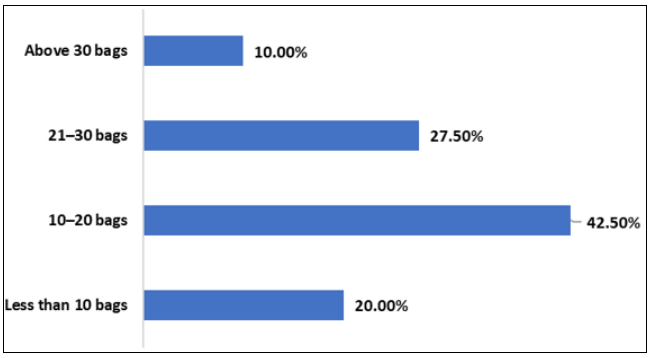


Source: Primary Data, 2025

Fig 5: Land Size Under Maize Cultivation (2023/2024 Season)

Findings show that the largest group of farmers, 32 respondents (40.0%), cultivated 1–2 hectares of maize, while 28 respondents (35.0%) worked on less than 1 hectare. A further 14 respondents (17.5%) cultivated 2.1–3 hectares, and only 6 respondents (7.5%) operated fields above 3 hectares.

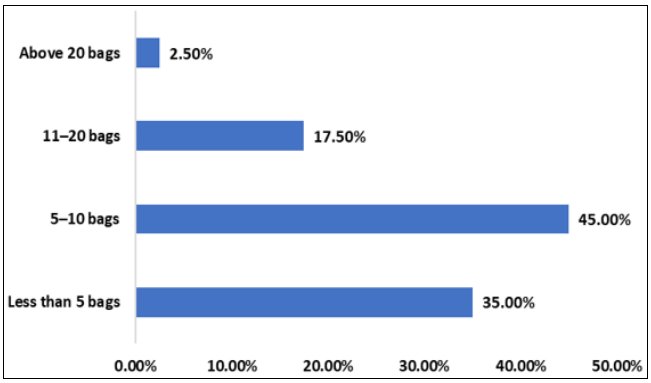
4.2 The Effects of Drought on Maize Yields Among Small-Scale Farmers



Source: Primary Data, 2025

Fig 6: Maize Yield in a Normal Rainfall Year

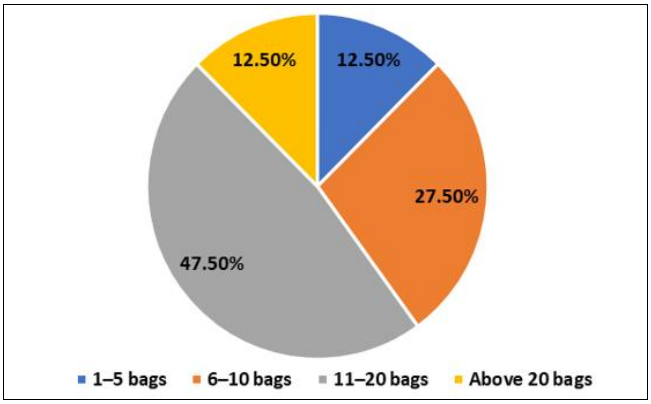
Fig 6 shows that 34 farmers (42.5%) produced 10–20 bags of maize in a normal rainfall year, while 22 farmers (27.5%) harvested 21–30 bags. Additionally, 16 farmers (20.0%) obtained less than 10 bags, and only 8 farmers (10.0%) exceeded 30 bags. FGD participants reported that favourable rainfall enabled households to meet consumption needs and retain surplus. Agricultural extension officers and cooperative leaders added that normal seasons in Ibenga generally support stable yields, especially for farmers cultivating at least one hectare.



Source: Primary Data, 2025

Fig 7: Maize Yield in the 2023/2024 Drought Year

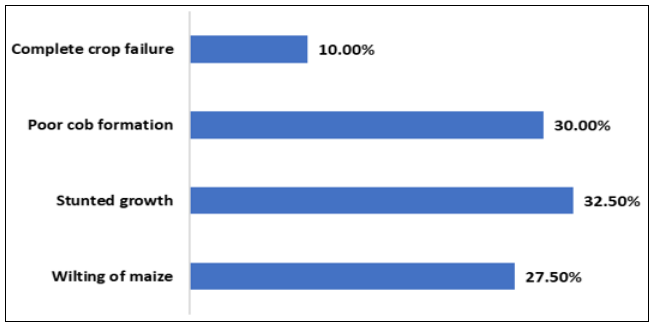
Fig 7 indicates a marked reduction in maize output during the 2023/2024 drought year. A total of 36 farmers (45.0%) harvested 5-10 bags, while 28 farmers (35.0%) produced less than 5 bags. Only 14 farmers (17.5%) managed 11-20 bags, and just 2 farmers (2.5%) exceeded 20 bags. FGD participants reported that extended mid-season dry spells hindered cob development. Agricultural extension officers and cooperative leaders added that the drought nearly halved yields for households relying solely on rain-fed production.



Source: Primary Data, 2025

Fig 8: Drought-Related Reduction in Maize Yield

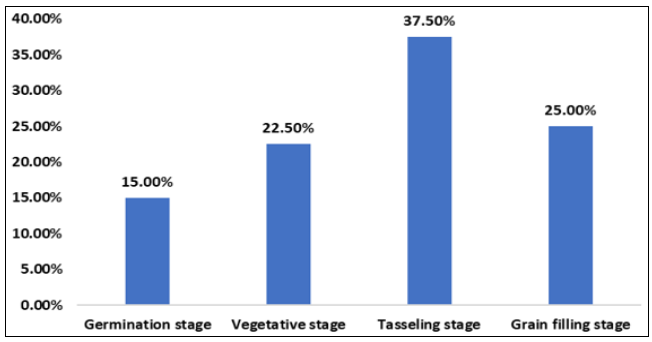
Findings shows that the largest group of farmers, 38 respondents (47.5%), experienced a drought-related reduction of 11-20 bags, while 22 farmers (27.5%) reported losses of 6-10 bags. A further 10 farmers (12.5%) lost 1-5 bags, and another 10 (12.5%) recorded reductions exceeding 20 bags. FGD participants linked these declines to erratic rainfall during tasseling. Agricultural extension officers and cooperative leaders confirmed that many households experienced yield drops of more than one-third compared to normal seasons.



Source: Primary Data, 2025

Fig 9: Main Drought Impact Experienced on Maize Fields

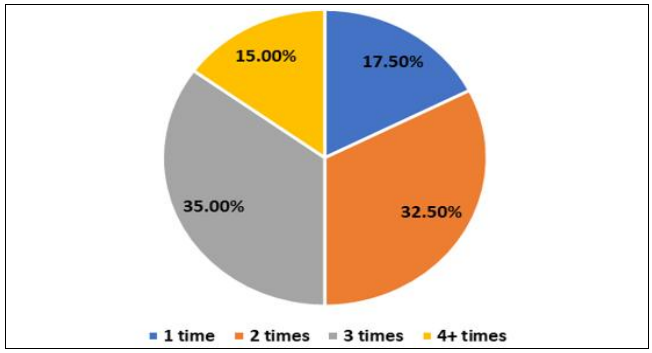
Fig 9 shows that the most frequently reported drought impact was stunted growth, affecting 26 farmers (32.5%). This was followed by poor cob formation reported by 24 farmers (30.0%) and wilting of maize experienced by 22 farmers (27.5%). Complete crop failure was recorded by 8 farmers (10.0%). FGD participants, comprising 15 small-scale farmers, described severe moisture stress limiting plant development. Agricultural extension officers confirmed that poor cob formation was widespread in 2023/2024, directly contributing to reduced harvest volumes.



Source: Primary Data, 2025

Fig 10: Growth Stage Most Affected by Drought

Results show that the tasseling stage was most affected, with 30 farmers (37.5%) reporting severe drought stress. This was followed by the grain-filling stage, affecting 20 farmers (25.0%), and the vegetative stage, affecting 18 farmers (22.5%). Only 12 farmers (15.0%) experienced major impacts at germination. FGD participants, comprising 15 small-scale farmers, noted that moisture loss during tasseling reduced kernel formation. Agricultural extension officers, cooperative leaders, and community leaders confirmed tasseling as the most drought-sensitive stage in Ibenga.

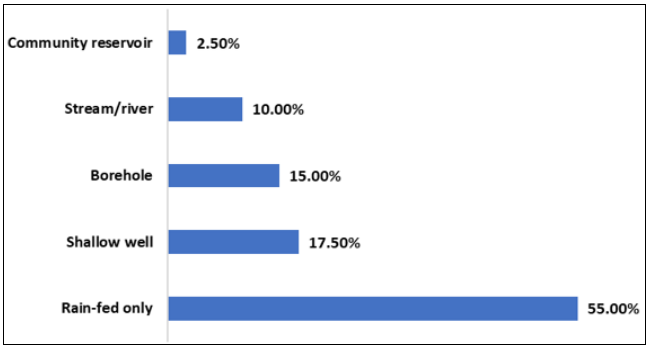


Source: Primary Data, 2025

Fig 11: Frequency of Drought Events in the Past Five Seasons

Fig 11 indicates that 28 farmers (35.0%) experienced drought three times in the past five seasons, while 26 farmers (32.5%) encountered drought twice. Additionally, 14 farmers (17.5%) reported a single drought event, and 12 farmers (15.0%) experienced drought four or more times. FGD participants, consisting of 15 small-scale farmers, noted increasing rainfall unpredictability. Agricultural extension officers, cooperative leaders, and Ward Development Committee members confirmed a rising drought trend with cumulative effects on soil moisture and maize yield performance.

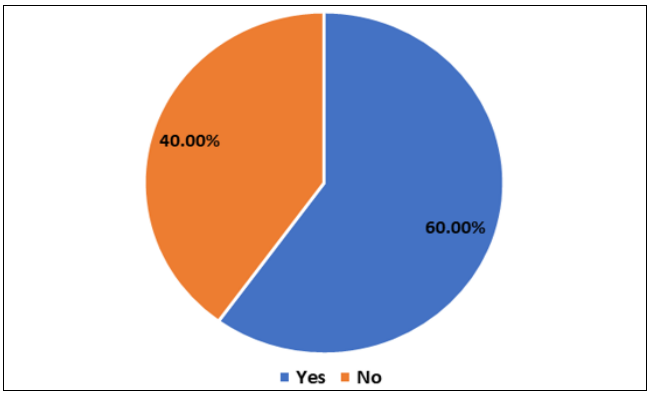
4.3 Coping Strategies Used by Farmers to Mitigate Drought Effects



Source: Primary Data, 2025

Fig 12: Main Source of Water Used for Maize Production in Drought Years

44 farmers (55.0%) relied entirely on rain-fed production during drought years, while 14 farmers (17.5%) used shallow wells and 12 (15.0%) drew water from boreholes. Only 8 farmers (10.0%) used streams or rivers, and 2 (2.5%) accessed community reservoirs. FGD participants, comprising 15 small-scale farmers, noted that wells often dry up during peak drought periods. Agricultural extension officers and cooperative leaders confirmed that Ibenga Ward has minimal irrigation infrastructure, reinforcing dependence on rainfall.

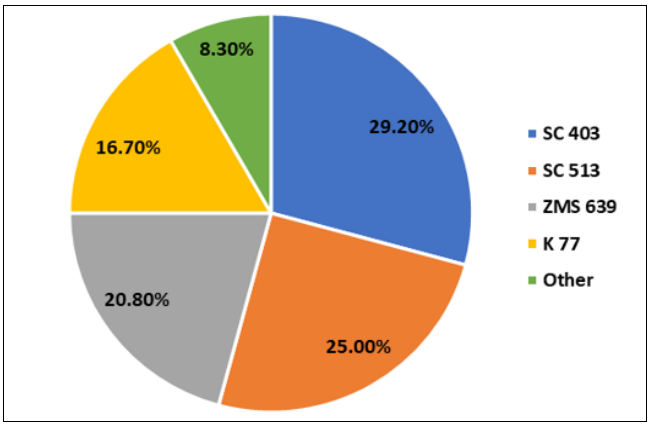


Source: Primary Data, 2025

Fig 13: Use of Drought-Tolerant Maize Seed

60.0% of farmers used drought-tolerant maize seed in the 2023/2024 season, while 32 farmers (40.0%) did not adopt such varieties. FGD participants reported that non-adopters faced seed affordability challenges and inconsistent supply through cooperatives. Agricultural extension officers, cooperative leaders, and Ward Development Committee members confirmed that despite ongoing promotion of

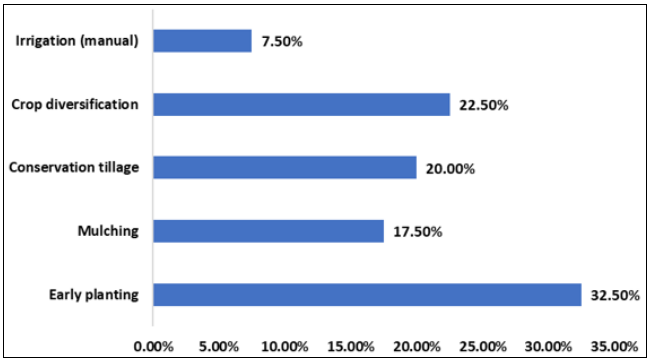
drought-tolerant varieties in Mpongwe District, distribution gaps persist. Farmers who accessed improved seed observed relatively better survival during prolonged dry spells.



Source: Primary Data, 2025

Fig 14: Type of Drought-Tolerant Seed Used

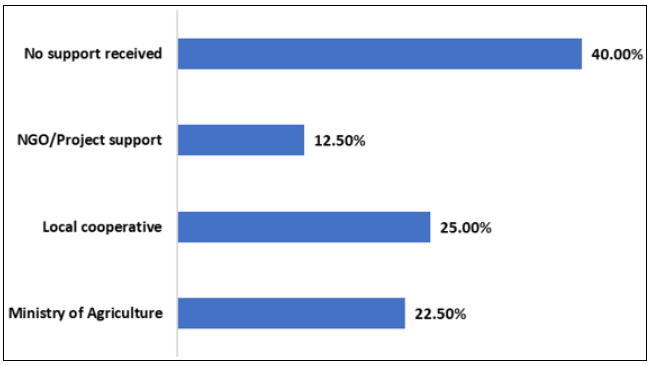
Among the 48 farmers who used drought-tolerant maize, Fig 14 shows that SC 403 was planted by 14 farmers (29.2%), followed by SC 513 with 12 farmers (25.0%). ZMS 639 was used by 10 farmers (20.8%), K 77 by 8 farmers (16.7%), while 4 farmers (8.3%) chose other varieties. FGD participants stated that these seeds mature faster and withstand mid-season stress. Agricultural extension officers and cooperative leaders confirmed that SC 403 is widely distributed through government programmes, though yields still decline under severe drought.



Source: Primary Data, 2025

Fig 15: Common Drought Coping Strategy

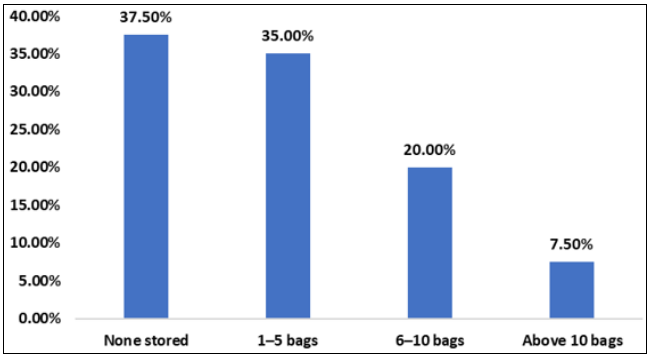
Early planting was the most common coping strategy, used by 26 farmers (32.5%). Crop diversification was applied by 18 farmers (22.5%), while 16 farmers (20.0%) practiced conservation tillage. Mulching was used by 14 farmers (17.5%), and only 6 farmers (7.5%) engaged in manual irrigation. FGD participants explained that early planting helps capture the first rains, while diversification spreads risk. Agricultural extension officers and NGO representatives noted growing awareness of conservation agriculture, although adoption is slowed by labour constraints and limited training.



Source: Primary Data, 2025

Fig 16: Source of Support Received for Drought Coping

32 farmers (40.0%) received no support during the previous season. Local cooperatives assisted 20 farmers (25.0%), mainly through access to seed and limited inputs. The Ministry of Agriculture supported 18 farmers (22.5%) through extension advice and occasional input distribution, while 10 farmers (12.5%) benefited from NGO or project support. FGD participants reported irregular training and undersupplied seed programmes. Agricultural extension officers, cooperative leaders, and NGO representatives confirmed that resource shortages limit comprehensive drought-response outreach across Ibenga Ward.



Source: Primary Data, 2025

Fig 17: Household Buffer Stock Stored

30 farmers (37.5%) had no buffer stock at all, while 28 farmers (35.0%) stored only 1–5 bags. Another 16 farmers (20.0%) managed 6–10 bags, and just 6 farmers (7.5%) stored more than 10 bags. FGD participants reported that most households exhaust their maize reserves earlier than usual in drought years. Agricultural extension officers and community leaders confirmed that limited storage increases dependence on market purchases, heightening household vulnerability to food shortages.

4.4 The Effects of Low Maize Yields on Food Security Among Small-Scale Farmers

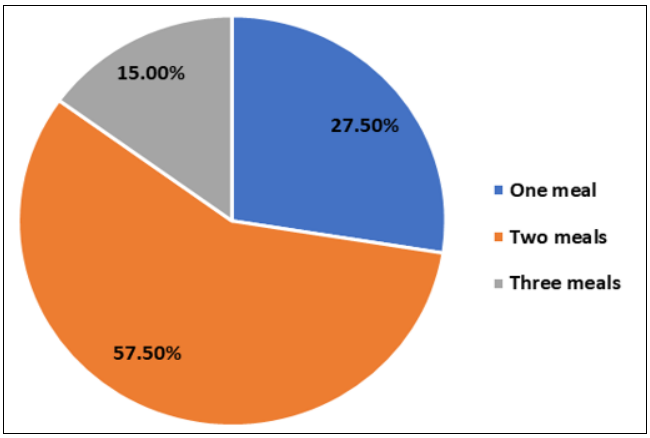
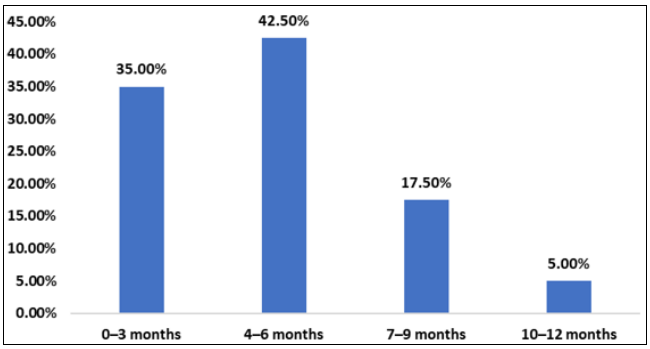


Fig 18: Number of Daily Meals Consumed During the Drought Season

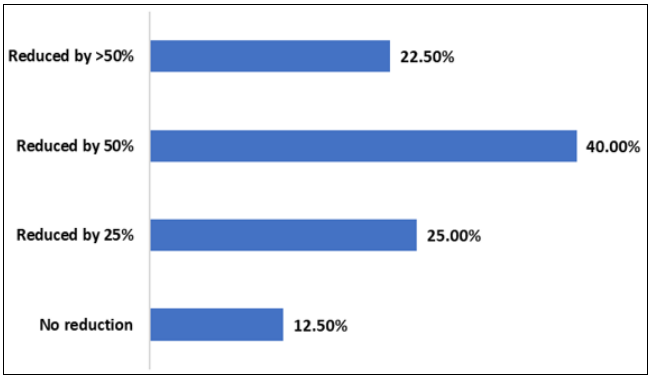
46 households (57.5%) consumed two meals per day during the drought season, while 22 households (27.5%) reduced intake to one meal. Only 12 households (15.0%) managed three meals. FGD participants indicated that reductions typically begin around February when maize stocks run out. Agricultural extension officers and cooperative leaders noted that households depending entirely on rain-fed maize production experience the sharpest drops in meal frequency, directly reflecting yield losses from the 2023/2024 drought.



Source: Primary Data, 2025

Fig 19: Months of Adequate Household Food Provisioning (MAHFP)

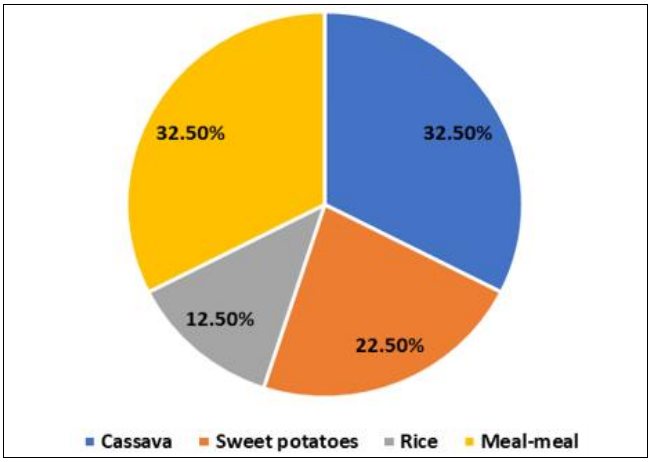
34 households (42.5%) had adequate food for only 4-6 months, while 28 households (35.0%) managed just 0-3 months. Fourteen households (17.5%) had enough food for 7-9 months, and only 4 households (5.0%) reached year-round sufficiency. FGD participants attributed shortened provisioning to reduced maize harvests and rising meal-meal prices. Agricultural extension officers and Ward Development Committee members emphasized that declining yields intensify reliance on purchased food, heightening the risk of seasonal hunger.



Source: Primary Data, 2025

Fig 20: Reduction in Household Maize Consumption Due to Low Yields

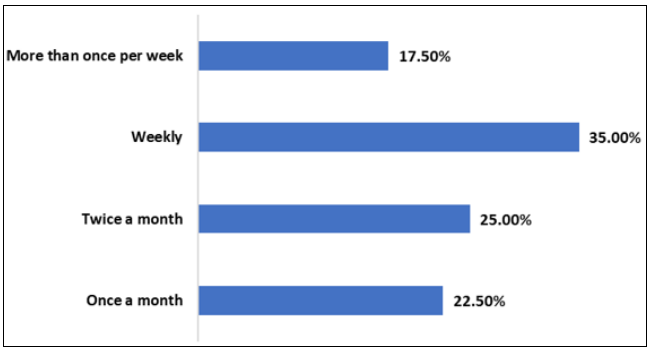
32 households (40.0%) reduced their maize consumption by 50%, while 18 households (22.5%) cut consumption by more than 50%. Another 20 households (25.0%) reduced intake by 25%, and only 10 households (12.5%) reported no reduction. FGD participants explained that many families ration maize flour and substitute nshima with porridge or other lighter meals. Agricultural extension officers and cooperative leaders confirmed that the sharp consumption declines reflect reduced yields from the 2023/2024 drought.



Source: Primary Data, 2025

Fig 21: Main Food Purchased to Substitute Maize During Shortages

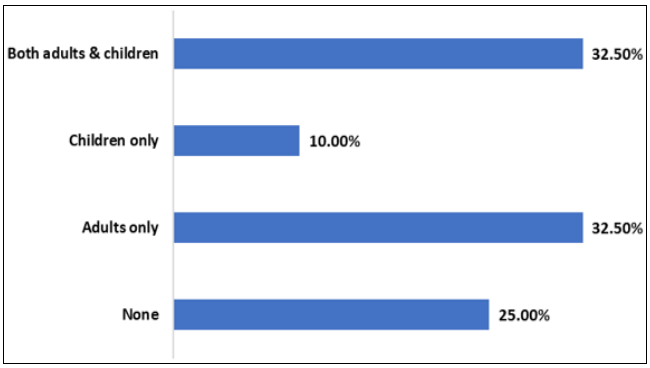
Cassava and purchased meal-meal were the most common substitutes, each used by 26 households (32.5%). Sweet potatoes were purchased by 18 households (22.5%), while 10 households (12.5%) relied on rice. FGD participants explained that cassava is widely accessible and cheaper than meal-meal, making it a practical substitute during shortages. Agricultural extension officers and local community leaders noted increased reliance on purchased meal-meal despite rising prices, signaling decreasing household self-sufficiency as maize yields decline.



Source: Primary Data, 2025

Fig 22: Frequency of Purchasing Maize Meal During the Drought Period

28 households (35.0%) bought maize meal weekly, while 14 households (17.5%) purchased it more than once per week, showing high dependence on market supplies. Twenty households (25.0%) purchased meal-meal twice a month, and only 18 households (22.5%) bought it once a month. FGD participants revealed that most households purchase small quantities because of inconsistent income. Cooperative leaders and NGO representatives confirmed that rising reliance on purchased meal-meal corresponds with earlier depletion of household maize stocks.



Source: Primary Data, 2025

Fig 23: Household Members Who Skipped Meals Due to Low Maize Availability

26 households (32.5%) reported both adults and children skipping meals, while another 26 households (32.5%) indicated skipping among adults only. Eight households (10.0%) reported that only children skipped meals, and 20 households (25.0%) experienced no skipping. FGD participants explained that adults commonly skip meals first to preserve food for children. Agricultural extension officers and Ward Development Committee members reported rising cases of meal skipping during drought years, emphasizing the deepening food insecurity linked to declining maize yields.

4.5 Discussion of Results

4.5.1 The Effects of Drought on Maize Yields Among Small-Scale Farmers

The findings showed that drought severely affected maize yields among small-scale farmers in Ibenga Ward, leading to substantial declines during the 2023 and 2024 season. Farmers who normally produced moderate yields experienced significant losses, with many reporting reductions of between 11 and 20 bags, while others harvested fewer than 5 bags. The most affected stages were tasseling and grain filling, where 37.5 percent of farmers observed the greatest damage, resulting in poor pollination and weak cob formation. These outcomes closely reflected regional studies that identified similar physiological stress during mid-season dry spells as the main driver of yield decline. Farmers also reported stunted growth and wilting across multiple stages, confirming that drought impacts extended from germination to maturity. The recurrence of drought over the last five seasons further indicated a shift toward persistent climatic stress, weakening soil moisture and reducing overall productive capacity for small-scale farmers in Ibenga Ward.

4.5.2 Coping Strategies Used by Farmers to Mitigate Drought Effects

The study revealed that small-scale farmers in Ibenga Ward employ a mix of traditional, agronomic, and externally supported strategies to cope with drought, yet face structural and institutional constraints. Most farmers, 55 percent, relied on rain-fed production, reflecting limited irrigation and water infrastructure, which restricted adaptive options. Adoption of drought-tolerant maize varieties was observed among 60 percent of farmers, improving survival and yield stability, while cost and distribution barriers limited uptake for others. Agronomic practices such as early planting, crop diversification, mulching, and conservation tillage provided adaptive flexibility, though only 7.5 percent accessed manual irrigation due to infrastructural limits. Institutional support was uneven, with 40 percent of farmers receiving no assistance, highlighting gaps in extension and cooperative services. Household buffer stocks were low, with 72.5 percent storing fewer than five bags of maize, indicating limited capacity to maintain food security. Overall, coping strategies were innovative but insufficiently robust, constrained by systemic and environmental challenges.

4.5.3 The Effects of Low Maize Yields on Food Security Among Small-Scale Farmers

The study revealed that low maize yields in Ibenga Ward severely compromised household food security, affecting availability, access, utilization, and stability. During the drought season, most households consumed only one or two meals daily, with adequate food stocks lasting three to six months, forcing early reliance on markets. Many substituted maize with cassava, sweet potatoes, or purchased maize meal, reflecting nutritional compromises and reduced dietary diversity. Adult-first meal skipping was common, though some children also missed meals, indicating critical food stress. Households became increasingly exposed to price volatility and income constraints as grain reserves depleted, mirroring broader Sub-Saharan patterns. The results highlight that maize-dependent households are highly sensitive to yield fluctuations, and recurring droughts exacerbate vulnerability across seasons. These findings underscore the need for structural interventions, including drought-tolerant seeds, small-scale irrigation, improved storage, market stabilization, and diversified crop production, to strengthen resilience and mitigate the cascading effects of maize yield declines on food security in Ibenga Ward.

5. Conclusion

The study examined the effects of drought on maize production among small-scale farmers in Ibenga Ward, focusing on yield performance, coping strategies, and household food security. Findings revealed that drought has

become a recurrent and increasingly severe challenge, significantly disrupting maize production and threatening livelihoods. Critical growth stages, particularly tasseling and grain filling, were most affected by moisture stress, leading to stunted growth, poor cob formation, and, in some cases, complete crop failure. Many farmers experienced yield reductions exceeding one-third compared to normal rainfall years, highlighting the vulnerability of rain-fed systems and limited alternative water sources. Farmers employed various coping strategies, including early planting, drought-tolerant seeds, conservation tillage, mulching, and crop diversification. However, many still relied solely on rainfall, lacked access to improved seeds or irrigation technologies, and received inadequate institutional support from cooperatives, government agencies, and NGOs. Declining maize yields directly contributed to heightened food insecurity. Households reported reducing meals, shortening food availability, increasing reliance on market purchases, and substituting maize with cassava and sweet potatoes. Meal skipping, affecting both adults and children, underscored severe food shortages. The study concludes that drought has interconnected impacts on maize production, adaptive capacity, and food security. Comprehensive interventions are urgently needed to enhance climate resilience, improve access to inputs, strengthen institutional support, and diversify livelihoods to safeguard productivity and household well-being in Ibenga Ward.

5.1 Recommendations

To enhance drought resilience and agricultural sustainability among small-scale farmers in Ibenga Ward, it is recommended that access to drought-tolerant seeds and small-scale irrigation be strengthened through improved distribution, subsidized inputs, and targeted support programmes. Agricultural extension services should be expanded to provide ongoing training on conservation agriculture, water management, crop diversification, and climate-resilient practices. Community-based grain storage and buffer stock facilities should be established to stabilize food availability during droughts. Institutional coordination among government departments, cooperatives, and NGOs must be improved to ensure timely support and capacity-building, while household and community livelihood diversification should be promoted to reduce reliance on maize and enhance resilience to climate shocks.

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