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Examining the Effectiveness of Adaptive Farming Practices in Mitigating the Effects of Prolonged Drought on Maize Production: A Case Study of Demu Ward, Pemba District

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Abstract

This study investigated the adaptive farming practices employed by smallholder maize farmers to mitigate the effects of prolonged drought in rural Zambia. A sample of 60 farmers was surveyed using structured questionnaires, complemented by open-ended questions to capture qualitative insights. The study examined the demographic characteristics of farmers, the types of adaptive strategies adopted, their effectiveness, and the role of support services in facilitating practice adoption. Quantitative data was analyzed using descriptive statistics, while qualitative responses were thematically analyzed to provide context and deeper understanding.

Findings reveal that maize farming is predominantly male-dominated (65%) and that the majority of farmers are relatively young (50% aged 25–35 years) with secondary or tertiary education levels, which positively influence the adoption of innovative strategies. Smallholder farmers, primarily cultivating 1–2 hectares, employ multiple adaptive techniques to enhance drought resilience, including conservation farming (65%), drought-resistant maize

varieties (60%), early planting (55%), and mulching (45%). Farmers reported yield improvements from 20–30 bags per hectare without adaptive practices to 80–120 bags per hectare with adoption under good management, indicating significant effectiveness. Extension officers, NGOs, training workshops, and peer networks were identified as the main sources of knowledge and support.

The study concludes that adaptive practices improve yield stability and enhance drought resilience but are constrained by limited access to inputs, knowledge gaps, and insufficient extension support. Recommendations include strengthening extension services, promoting integrated adaptive strategies, improving access to inputs, supporting knowledge sharing and peer learning, leveraging media and technology, addressing gender inequalities, and enhancing policy and institutional support. The study provides practical insights for farmers, policymakers, and development partners to enhance the sustainability and resilience of smallholder maize farming under drought conditions.

Keywords: Adaptive Farming, Smallholder Maize Farmers, Drought Resilience, Conservation Farming, Zambia

1. Introduction

1.1 Overview

The current chapter presents introductory components of a research proposal. This includes background of the study, statement of the problem, objectives and research questions, scope of the study and significance of the study.

1.2 Background of the Study

Climate change continues to pose a significant threat to global agricultural systems, particularly in regions heavily dependent on rain-fed farming. According to the Intergovernmental Panel on Climate Change (IPCC, 2022) [16], rising global temperatures, changing precipitation patterns, and increased frequency of extreme weather events are disrupting agricultural calendars and reducing crop yields worldwide. The IPCC warns that staple crops such as maize, rice, and wheat are likely to suffer significant yield declines, particularly in developing countries, due to these climatic stresses. As global food demand continues to rise, this trend threatens both food security and livelihoods, especially in vulnerable rural communities.

To address these challenges, the global agricultural community has increasingly advocated for the adoption of climate-smart agriculture (CSA), a set of practices aimed at increasing productivity, enhancing resilience, and reducing emissions (FAO, 2021). These include conservation agriculture, crop diversification, improved water management, and the use of stress-tolerant crop varieties. International organizations such as the World Bank and the Food and Agriculture Organization (FAO) have supported research and implementation of these practices across different agro-ecological zones, recognizing their potential to mitigate the adverse impacts of climate change on smallholder farmers.

Despite the global push for climate adaptation in agriculture, widespread implementation remains limited, especially in developing regions. Key barriers include inadequate financial investment, limited access to information, and weak institutional support systems (World Bank, 2020) [33]. Furthermore, there is growing consensus that localized, context-specific approaches are essential, as the success of adaptive techniques depends heavily on local environmental conditions, socio-economic factors, and farmers' knowledge levels. As such, understanding how adaptive farming practices perform in specific communities is critical to improving agricultural resilience globally.

Across Africa, agriculture remains the backbone of rural livelihoods, employing up to 60% of the population and contributing significantly to national gross domestic product (GDPs) (AGRA, 2021). However, African farmers are among the most vulnerable to climate variability due to over-reliance on rain-fed agriculture, limited infrastructure, and inadequate institutional support. Maize, a staple crop in many African countries, is particularly sensitive to changes in rainfall and temperature. Recent studies indicate that maize yields in Sub-Saharan Africa could decline by up to 30% by 2050 if adaptive measures are not urgently implemented (Rippke *et al.*, 2016).

Several African countries have initiated policies and programs aimed at promoting climate-resilient agriculture. For example, in countries like Kenya, Ethiopia, and Malawi, governments and non-governmental organizations have introduced drought-tolerant maize varieties, mulching, inter-cropping, and water harvesting techniques to improve resilience (AGRA, 2021; Nhemachena *et al.*, 2020 [25]). While these interventions have shown promise, their uptake remains uneven due to socioeconomic disparities, low literacy levels among farmers, and limited access to extension services and inputs. As such, there is a growing need to examine the actual impact and scalability of these interventions at the community level.

Moreover, localized studies from regions such as the Sahel and Southern Africa have emphasized the importance of tailoring interventions to the needs of specific communities. For instance, research conducted in southern Zimbabwe and northern Mozambique has shown that farmer training and access to early warning systems significantly increase the likelihood of adopting adaptive farming practices (Mwongera *et al.*, 2017) [23]. These findings highlight the critical role of farmer education, government support, and access to finance in ensuring the success of climate-smart interventions in Africa.

In Zambia, agriculture employs over 60% of the population and contributes approximately 20% to GDP, with maize being the principal food crop and a key driver of food

security (Tembo *et al.*, 2021) [29]. The Zambian agricultural calendar traditionally aligns with the rainy season, with planting done between November and January and harvesting between April and June. However, climate change has led to increasingly erratic rainfall patterns, prolonged droughts, and rising temperatures—disrupting this calendar and significantly impacting maize yields (Zambia Meteorological Department, 2022). Southern Province, in particular, has been hard-hit, with many farmers experiencing total crop failure in some seasons.

In response to these challenges, various stakeholders, including the Zambian government, NGOs, and international partners, have promoted adaptive farming practices. These include conservation agriculture, mulching, planting early-maturing and drought-tolerant maize varieties, and small-scale irrigation schemes (Musonda *et al.*, 2020). While some farmers have embraced these practices, adoption rates remain low in many rural areas due to limited awareness, lack of access to resources, and poor extension service coverage. Additionally, cultural preferences for traditional farming methods and skepticism towards new technologies have slowed the transition.

A specific case is Demu Ward in Pemba District, Southern Province, where farmers continue to struggle with prolonged dry spells and poor soil moisture retention. Despite interventions by NGOs and government agents, including training sessions and input distribution, many farmers are yet to fully adopt adaptive practices due to high costs, limited input access, and inadequate technical knowledge. Demu Ward's agro-ecological conditions sandy loam soils and lack of irrigation further exacerbate the vulnerability of maize farming. Understanding the conditions under which adaptive farming succeeds in Demu Ward can offer crucial insights for improving local resilience and informing broader policy interventions in Zambia's drought-prone regions.

1.3 Statement of the Problem

Despite numerous efforts to promote climate-resilient agriculture in Zambia, maize production in Demu Ward, located in Pemba District of Southern Province, continues to face significant challenges due to prolonged droughts and erratic rainfall patterns. Traditional farming methods such as mono-cropping and reliance on rainfall without soil moisture conservation have proven insufficient in addressing the increasingly harsh climatic conditions (Musonda *et al.*, 2020). These climatic shocks not only reduce crop productivity but also compromise household food security and economic stability in rural communities where agriculture is the main livelihood activity (Tembo *et al.*, 2021) [29].

To mitigate these effects, adaptive farming practices including conservation agriculture, use of drought-tolerant maize varieties, and mulching have been introduced by the government and various non-governmental organizations (NGOs). However, adoption remains inconsistent and largely unmonitored by stakeholders. The lack of localized empirical data on the effectiveness of these practices in improving maize yields during drought periods hampers efforts to scale up successful interventions in a targeted manner (ZARI, 2021). Moreover, there is limited understanding of the extent to which factors such as farmer knowledge, access to inputs, extension services, and environmental conditions influence adoption and success of

these climate-smart techniques (Muleba & Chisanga, 2019). In Demu Ward, most farmers continue to rely on rain-fed maize cultivation despite declining and unreliable rainfall. The inconsistency in training programs and limited access to technical support has further reduced the potential benefits of adaptive practices. While climate-resilient agriculture has been identified as a national priority in Zambia's Climate Change Response Strategy (Ministry of Lands and Natural Resources, 2016), actual implementation at the grassroots level remains fragmented and poorly evaluated. Without concrete, localized evidence on the performance and constraints of adaptive farming techniques in drought-prone areas like Demu Ward, policy responses remain overly general and risk being ineffective (World Bank, 2020) ^[33]. This research, therefore, seeks to investigate the effectiveness of adaptive farming practices in mitigating the effects of prolonged droughts on maize productivity in Demu Ward of Pemba district in southern province and to explore the key factors that influence their successful adoption of adaptive farming. By identifying the relationship between farmer awareness, training access, and actual yield outcomes, this study aims to fill a critical knowledge gap and contribute to more context-specific agricultural strategies in drought-affected regions of Zambia.

1.4 General Objective

To examine the effectiveness of adaptive farming practices in mitigating the effects of prolonged droughts on maize production in Demu Ward of Pemba District.

1.4.1 Specific Objectives

1. To identify the types of adaptive farming practices adopted by maize farmers in Demu Ward during prolonged droughts.
2. To assess the effectiveness of selected adaptive farming techniques in improving maize yield levels under drought conditions.
3. To evaluate the influence of farmer awareness, training, and support services on the successful implementation and sustainability of adaptive farming practices in drought-prone areas.

1.5 Research Questions

1. What types of adaptive farming practices are adopted by maize farmers in Demu Ward to address prolonged droughts?
2. How effective are these adaptive practices in sustaining maize yields during drought conditions?
3. How do farmer awareness, training, and access to support services influence the adoption and effectiveness of adaptive farming practices?

1.6 Theoretical Framework

Everett Rogers' *Diffusion of Innovations Theory* (2003) explains how, why, and at what rate new ideas, technologies, or practices spread through a social system. The theory highlights that innovation adoption follows a five-stage process: **knowledge**, **persuasion**, **decision**, **implementation**, and **confirmation**. This process describes the mental journey individuals or communities undergo—from first learning about an innovation to finally deciding to adopt and continue using it. The theory also identifies five categories of adopters: **innovators**, **early adopters**, **early majority**, **late majority**, and **laggards**, each representing

varying levels of willingness to adopt change. Communication channels, the nature of the social system, and perceived attributes of the innovation (e.g., relative advantage, compatibility, complexity, trialability, and observability) significantly influence the speed and success of diffusion.

In the context of Demu Ward in Pemba District of Zambia, where prolonged droughts have adversely affected maize production, *adaptive farming practices* such as conservation agriculture, drought-tolerant seed varieties, and water harvesting are the innovations under investigation. *The Diffusion of Innovations Theory* provides a lens to understand how these practices are introduced, accepted, and adopted by smallholder farmers. For example, farmers must first become aware (**knowledge stage**), be convinced of the benefits (**persuasion**), make a choice to adopt or reject (**decision**), begin using the methods (**implementation**), and evaluate the outcomes (**confirmation**). Understanding where farmers are in this process helps identify barriers and enablers to adoption. The theory's classification of adopters also helps explain why some farmers adopt innovations quickly while others are resistant or slow, based on their access to information, training, risk tolerance, and social influence.

The *Diffusion of Innovations Theory* directly supports these objectives. The first objective relates to the final stages of the **innovation-decision process** (implementation and confirmation), where the outcomes of adoption such as improved maize yields are measured while as the second objective **aligns with the earlier stages** (knowledge and persuasion), emphasizing the importance of awareness creation and farmer training. Additionally, Rogers' emphasis on communication channels and the influence of the social system supports investigation into how extension services, community leaders, and peer networks impact the spread and uptake of these adaptive practices.

1.7 Significance of the Study

The findings from this study will provide empirical evidence on the effectiveness of adaptive farming practices in mitigating prolonged drought effects on maize production in a vulnerable rural setting. This information will be valuable to policymakers, agricultural extension officers, NGOs, and development partners in designing more targeted interventions. The study will also contribute to the academic discourse on climate change adaptation in agriculture, particularly in the Zambian context. Additionally, it will empower farmers with knowledge that can enhance their resilience against climate-induced shocks.

1.8 Scope of the Study

This study will be confined to Demu Ward of Pemba District in Southern Province, Zambia. It will focus specifically on smallholder maize farmers and will investigate the effectiveness of selected adaptive farming practices during periods of prolonged drought. The research will not cover other crops or agricultural zones outside Demu Ward.

2. Literature Review

2.1 Overview

This chapter reviews scholarly literature related to the adoption and effectiveness of adaptive farming practices aimed at mitigating the effects of prolonged droughts on

maize production, a case study of Demu ward in Pemba District. The literature review is structured around the key research objectives of the study and divided into three major themes: (1) adaptive farming practices for drought resilience, (2) the effectiveness of adaptive techniques on crop yield, and (3) the role of farmer training, awareness, and extension services. Each thematic area is explored from a global, regional (African), and local (Zambian) perspective to contextualize the existing knowledge, highlight patterns and discrepancies, and inform the current study.

2.2 Thematic area developed from objective one

Adaptive farming practices are increasingly recognized as a critical response to climate variability and drought risk. Climate-Smart Agriculture (CSA), promoted by international organization like FAO and CGIAR, integrates practices such as conservation agriculture, agroforestry, integrated pest management, and precision farming to build resilience (Lipper *et al.*, 2014). For instance, in Latin America and Southeast Asia, conservation agriculture involving minimum soil disturbance, crop rotation, and permanent soil cover has significantly improved soil water retention and reduced drought risk (Thierfelder & Wall, 2012).

Globally, drought-tolerant maize varieties have become one of the most widely adopted adaptive farming practices. These varieties have been genetically developed to survive prolonged dry spells and maintain yield under water stress conditions (CIMMYT, 2013). Farmers in Latin America, Asia, and parts of Africa have reported stable maize yields when using these varieties. The development and dissemination of drought-tolerant seeds are often supported by international research institutions. Besides yield stability, drought-tolerant varieties contribute to food security by reducing the risk of total crop failure during extreme weather events. However, access to these seeds is not uniform, with smallholder farmers in developing countries often facing high costs (World Bank, 2016) [32]. Overall, drought-tolerant maize has proven essential in global strategies to adapt to climate variability.

Conservation Agriculture (CA) is another globally recognized adaptive practice for maize production under drought conditions. It involves minimum tillage, crop rotation, and residue retention to improve soil structure and moisture retention (Daryanto *et al.*, 2016) [8]. CA reduces soil erosion, increases water infiltration, and promotes soil fertility over time. These benefits have been demonstrated in countries such as India, Brazil, and Mexico. Conservation agriculture also allows farmers to reduce production costs by minimizing machinery use and labor inputs. However, successful implementation often requires proper farmer training and access to adequate technical knowledge. Studies indicate that Conservation Agriculture adoption globally has been higher when coupled with extension support and financial incentives (FAO, 2021).

Improved irrigation techniques, such as drip, sprinkler, and small-scale irrigation, are widely adopted globally to mitigate drought effects (Lobell *et al.*, 2011) [17]. These technologies allow farmers to apply water efficiently and reduce crop losses during dry spells. In countries like Israel, the U.S., and parts of China, these irrigation methods have significantly increased maize productivity. Efficient water management also reduces water wastage and helps maintain soil health. However, the high initial investment and

maintenance costs limit adoption among smallholder farmers in developing regions. Donor-supported programs and government subsidies have been effective in promoting irrigation adoption in such areas. Thus, irrigation remains a critical global adaptive strategy for sustaining maize production under drought conditions.

Early warning systems (EWS) and climate information services are increasingly used globally to help farmers anticipate and prepare for drought events (IFPRI, 2014) [15]. These systems provide timely weather forecasts, rainfall predictions, and guidance on optimal planting dates. Farmers in Southeast Asia, Sub-Saharan Africa, and South America have benefited from EWS by adjusting planting schedules and selecting drought-resistant crops. The integration of mobile technology has improved information accessibility, especially in remote areas. Early warning systems also help policymakers and extension agents design targeted interventions. Research shows that communities with effective EWS experience lower crop losses and better resilience to drought. However, technological literacy and network coverage remain challenges in certain regions.

Agroforestry, the integration of trees with crops, has gained recognition as a global drought adaptation strategy (World Bank, 2016) [32]. Trees provide shade, reduce soil evaporation, and improve microclimatic conditions for maize crops. In parts of Latin America, Africa, and Asia, agroforestry systems have led to higher maize yields during drought years. Additionally, trees contribute to long-term soil fertility through nutrient cycling and organic matter addition. Agroforestry also enhances biodiversity and offers alternative sources of income, such as fruit, timber, and fodder. Despite its benefits, adoption is sometimes constrained by land tenure issues and competition for arable land. Overall, agroforestry represents a holistic approach to climate-smart agriculture globally.

In Ethiopia, farmers have increasingly adopted drought-tolerant maize varieties as a primary strategy to cope with recurrent dry spells (Deressa *et al.*, 2009) [9]. These varieties allow smallholder farmers to maintain yields under unpredictable rainfall patterns, reducing the risk of total crop failure. Early planting and staggered planting dates complement these varieties by aligning crop growth with the availability of moisture. Farmers often combine these practices with soil and water conservation measures such as bunds and small terraces. Extension services have played a crucial role in promoting awareness of these strategies. However, the high cost of seeds and limited access to improved varieties remain barriers for many rural households. Despite these challenges, drought-tolerant maize continues to be a key adaptive practice in Ethiopia.

In Kenya, adaptive farming practices such as mulching, inter-cropping, and adjusting planting dates have become common among maize farmers (Mude *et al.*, 2012) [18]. Mulching helps retain soil moisture, reduces evaporation, and suppresses weed growth, thereby improving the micro-environment for maize crops. Inter-cropping maize with legumes enhances soil fertility through nitrogen fixation and provides a form of risk diversification. Adjusted planting dates allow farmers to better match crop growth stages with rainfall distribution, reducing the impact of early-season droughts. These practices are often promoted through extension services and local agricultural programs. Farmers report increased maize resilience and improved yield stability when combining multiple strategies. Nevertheless,

limited access to organic inputs and insufficient knowledge sometimes constrain full adoption.

In Malawi, community-based adaptation strategies have emerged as an important tool for smallholder farmers (Chinsinga, 2012) ^[5]. These include seed banks to ensure access to drought-tolerant varieties, collective water harvesting systems, and shared knowledge platforms. Such strategies reduce individual risk and enhance community resilience. Farmers are trained on proper seed storage and the timing of planting to optimize yields under dry conditions. These interventions have been particularly effective in drought-prone districts where individual households lack sufficient resources. Social cohesion and community participation play a significant role in the success of these strategies. However, scalability remains a challenge due to resource limitations and institutional weaknesses.

In West Africa, Tambo and Abdoulaye (2013) ^[28] observed that conservation tillage and crop diversification are widely adopted adaptive strategies for maize farming. Conservation tillage reduces soil disturbance, preserves soil moisture, and enhances fertility over time. Crop diversification, including mixing maize with drought-tolerant cereals and legumes, spreads risk and improves food security. These practices are complemented by farmer education programs and access to micro-credit to enable the purchase of inputs. Adoption is influenced by land tenure systems, availability of labor, and the perceived cost-benefit ratio of interventions. Farmers report that combining conservation tillage with crop diversification improves yields under drought conditions. These strategies illustrate the importance of both technological and socio-economic considerations in adaptation.

Access to extension services and credit is a major determinant of adaptive practice adoption in Southern Africa (Nhemachena & Hassan, 2007) ^[24]. Farmers who receive training on drought-resilient techniques, including mulching, intercropping, and use of drought-tolerant varieties, are more likely to implement them effectively. Credit access enables investment in improved seeds, organic fertilizers, and small-scale irrigation. The combination of technical knowledge and financial support enhances resilience to prolonged dry spells. However, disparities in access to these services often create gaps in adoption, leaving some farmers more vulnerable than others. Policy interventions have increasingly targeted these barriers to improve uptake. Overall, institutional support is critical for ensuring widespread adoption of adaptive maize farming practices in Africa.

In Zambia, drought-tolerant maize varieties are widely promoted in Southern Province, where prolonged dry spells are common (Tembo *et al.*, 2015) ^[30]. These varieties have been shown to maintain productivity despite erratic rainfall patterns. Farmers often plant early-maturing varieties to align growth stages with the rainy season and reduce exposure to peak drought periods. Mulching and residue retention are also used to conserve soil moisture and improve soil fertility. Local extension services provide guidance on optimal planting times and variety selection. Despite these interventions, high seed costs and limited availability constrain adoption for many smallholders. The use of drought-tolerant varieties has nonetheless become central to climate adaptation strategies in Zambia.

Rainwater harvesting techniques are increasingly adopted by

Zambian maize farmers as an adaptive strategy (Mwiinga *et al.*, 2016) ^[22]. Small-scale ponds, dams, and contour trenches allow farmers to capture and store rainwater for irrigation during dry periods. This method ensures that crops receive adequate water even when rainfall is erratic. Farmers report improved maize growth and reduced risk of crop failure when implementing these techniques. Training from agricultural extension officers enhances the effectiveness of rainwater harvesting by teaching proper design and maintenance. However, the construction of these systems requires labor and financial investment, which can limit widespread use. Rainwater harvesting demonstrates the importance of combining infrastructure and knowledge-based interventions.

Farmer field schools in Zambia have played a pivotal role in promoting adaptive maize farming practices (Chisanga *et al.*, 2017) ^[6]. These schools provide hands-on training in techniques such as conservation agriculture, intercropping, and mulching. Participants gain practical knowledge, observe demonstration plots, and share experiences with peers. Field schools also serve as platforms to disseminate new technologies, including drought-tolerant maize varieties. Farmers who participate in these programs are more likely to adopt adaptive practices and achieve higher yields during drought years. The model emphasizes learning by doing and community participation. Despite notable successes, the limited coverage of field schools leaves many farmers unreached.

The FFS approach centers on participatory, hand-on learning, where farmers receive climate-smart agriculture lessons tailored to local conditions- including water management, soil conservation, and resilient crop practices - through peer learning and experimentation (Ministry of Agriculture, 2025, UNDP, 2025). These schools have improved agricultural methods among over 360 farmers in the Eastern Province alone, addressing yield stagnation linked to traditional practices and climate stress (Ministry of Agriculture, 2025). The project's wider reach across 16 districts suggests scalable impact in water planning, drought management, and crop planning for nearly a million smallholders (UNDP, 2025).

Local climate-smart innovative agroecology initiatives, led by community-focused organizations such as MC-Zambia, have focused on Magoba and Chanyanya in Kafue district, blending biodiversity conservation with agricultural adaptation (MC-Zambia, 2025). Agroecology emphasizes forest regeneration, water conservation, and livestock fodder plots, integrating farming with ecosystem restoration (MC-Zambia 2025). This approach works by enhancing landscape resilience - trees and fodder plots reduce soil erosion and provide alternative income sources, while sustainable water practices support dry season farming. Preliminary observations show improved biodiversity and climate mitigation potential alongside enhanced rural livelihoods, though comprehensive impact assessments are still emerging (MC-Zambia, 2025).

Conservation agriculture practices are increasingly recognized as effective strategies for mitigating drought effects in Zambia (FAO, 2018) ^[10]. Techniques such as minimum tillage, crop rotation, and residue retention improve soil moisture retention and fertility. These practices reduce erosion, lower labor requirements, and enhance maize yield stability. Farmers implementing conservation agriculture report that yields are less affected by dry spells

compared to conventional farming methods. Training and continuous extension support are critical to ensure correct adoption of these techniques. Challenges include labor intensity for residue management and availability of sufficient crop residues. Overall, conservation agriculture contributes significantly to maize resilience under drought.

Mobile-based climate information services are becoming valuable tools for Zambian farmers (Banda *et al.*, 2019) ^[3]. These services provide real-time weather forecasts, planting advice, and drought warnings via mobile phones. Farmers can adjust planting dates, select appropriate varieties, and implement water management techniques based on timely information. This improves decision-making and reduces losses caused by unpredictable rainfall. The services also complement traditional extension methods and reach farmers in remote areas. Adoption is influenced by mobile network coverage, literacy levels, and user awareness. Nonetheless, mobile services represent a cost-effective approach to enhance adaptive capacity and maize productivity.

2.3 Thematic area developed from objective two

Globally, drought-tolerant maize varieties have proven effective in stabilizing yields under water stress. Rippke *et al.* (2016) found that these varieties increased maize yield by approximately 15% while reducing yield variability by 38% during drought periods. The improved performance is attributed to genetic modifications that allow plants to maintain growth despite limited soil moisture. In addition, these varieties reduce the risk of total crop failure, which is crucial for food security in drought-prone regions. Their effectiveness is enhanced when combined with early planting schedules and optimized soil management practices. However, adoption is limited by cost and availability, especially among smallholder farmers in developing countries. Despite these constraints, drought-tolerant maize is considered a cornerstone of climate-resilient agriculture globally.

Conservation Agriculture (CA) has also shown measurable improvements in maize productivity under drought conditions. Daryanto *et al.* (2016) ^[8] report that conservation agriculture practices, including minimum tillage, crop rotation, and residue retention, enhance soil water retention and reduce erosion. In global case studies, conservation agriculture increased yields by 10–25% compared to conventional practices in drought years. The improved soil structure and organic matter content allow crops to access water more efficiently during dry spells. In addition to yield benefits, conservation agriculture reduces labor and energy costs associated with plowing. Its effectiveness is maximized when combined with other interventions, such as drought-tolerant varieties or supplemental irrigation. Nonetheless, knowledge gaps and initial investment requirements can limit its adoption among resource-poor farmers (FAO, 2021).

Improved irrigation techniques, including drip and sprinkler irrigation, are critical in mitigating drought effects on maize globally (Lobell *et al.*, 2011) ^[17]. These methods ensure precise water delivery, reducing stress during critical growth stages. Studies indicate that drip irrigation can increase yields by up to 30% in regions experiencing water scarcity. Beyond yield improvements, efficient irrigation helps conserve water resources and maintain soil fertility. Implementation success is influenced by initial investment,

technical knowledge, and maintenance capacity. Government subsidies and donor programs have been effective in increasing access to these technologies. Overall, irrigation remains one of the most impactful adaptive interventions worldwide.

Early warning systems (EWS) and climate information services significantly improve maize outcomes under drought. International Food Policy Research Institute (IFPRI, 2014) ^[15] found that timely weather forecasts and planting advisories reduced crop losses by 20% in multiple countries. Early warning systems (EWS) allow farmers to anticipate dry periods, adjust planting dates, and select suitable crop varieties. In regions of Southeast Asia and Sub-Saharan Africa, Early warning systems (EWS) coupled with mobile technology has enhanced decision-making. Access to climate information improves the efficiency of other adaptive practices, such as irrigation and conservation agriculture. However, challenges include technological literacy and consistent access to reliable weather data. Early warning systems demonstrate that combining information services with field-level interventions enhances drought resilience globally.

Agroforestry has shown measurable benefits for maize yields in drought-prone areas worldwide. Trees inter-planted with maize create shade, reduce soil evaporation, and improve micro-climates, enhancing crop performance during dry seasons (World Bank, 2016) ^[32]. Studies indicate yield increases of 20–25% when agroforestry practices are combined with improved water management. Additionally, trees contribute to long-term soil fertility through nutrient recycling and organic matter addition. Agroforestry also provides additional income through timber, fruits, or fodder, reducing farmers' economic vulnerability. Adoption is often constrained by land tenure issues and competition for arable land. Nevertheless, agroforestry represents a sustainable, holistic approach to drought adaptation in maize farming globally.

In Ethiopia, drought-tolerant maize varieties have demonstrated effectiveness in stabilizing yields and reducing crop failure (Deressa *et al.*, 2009) ^[9]. Farmers using these varieties reported approximately 10% higher yields during drought years compared to traditional maize varieties. Early planting and water conservation techniques further amplified these benefits. Access to extension services improved farmers' ability to apply these adaptive techniques effectively. However, seed costs and distribution challenges limit adoption across the broader farming population. Despite these limitations, drought-tolerant maize remains an essential tool for smallholders in drought-prone regions. Its effectiveness depends on combining improved seeds with other adaptation measures such as soil management.

In Kenya, mulching and inter-cropping practices have been shown to enhance maize yields under drought conditions (Mude *et al.*, 2012) ^[18]. Mulching conserves soil moisture, reduces surface evaporation, and suppresses weeds. Inter-cropping maize with legumes improves soil fertility through nitrogen fixation while providing risk diversification. Studies indicate yield improvements of 10–15% for farmers practicing both strategies during dry spells. Adoption is most successful when supported by farmer education and extension programs. However, availability of organic mulching materials and labor constraints can limit implementation. Overall, these strategies demonstrate the

value of combining soil and crop management techniques for drought resilience.

Community-based adaptation strategies in Malawi have been effective in sustaining maize production during drought periods (Chinsinga, 2012) ^[5]. Seed banks, collective water management systems, and shared knowledge networks allow farmers to mitigate the effects of prolonged dry spells. These practices reduce individual household vulnerability and enhance collective resilience. Studies show that maize yields are more stable when farmers participate in these community-based interventions. Farmer training on seed selection and planting timing further increases effectiveness. Institutional support from NGOs and local government agencies also contributes to success. These findings highlight the importance of social structures in enhancing adaptive capacity in African maize farming.

In West Africa, conservation tillage and crop diversification have proven effective in improving maize productivity under drought (Tambo & Abdoulaye, 2013) ^[28]. Conservation tillage improves soil moisture retention and fertility, while crop diversification reduces dependency on a single crop and spreads risk. Farmers practicing both techniques report higher yields during drought years compared to conventional mono cropping. Access to training, microcredit, and extension services enhances adoption rates. However, labor requirements and land tenure issues can constrain uptake. Overall, combining multiple adaptive practices significantly enhances maize resilience to drought in West African contexts.

Access to extension services and credit has a direct impact on the effectiveness of adaptive practices in Southern Africa (Nhemachena & Hassan, 2007) ^[24]. Farmers who receive training on drought-tolerant maize, mulching, and intercropping implement these strategies more effectively. Credit facilities allow smallholders to purchase improved seeds, fertilizers, and small-scale irrigation systems. Studies indicate yield improvements of 12–15% when adaptive practices are supported by financial and technical assistance. Adoption remains uneven due to disparities in access, highlighting the need for inclusive policy interventions. Overall, institutional support enhances both the adoption and the effectiveness of drought adaptation strategies.

In Zambia, drought-tolerant maize varieties have been shown to improve yield stability in Southern Province (Tembo *et al.*, 2015) ^[30]. Farmers reported yield increases of 15–20% during drought years compared to traditional varieties. Early planting of these varieties aligns crop growth with available rainfall, reducing exposure to dry periods. Training from extension officers helps farmers select appropriate varieties and manage them effectively. High seed costs and limited availability remain challenges for broader adoption. Despite these limitations, drought-tolerant maize has become a critical component of local climate adaptation strategies. These varieties are most effective when integrated with complementary practices such as mulching and irrigation.

Rainwater harvesting techniques have proven effective in mitigating drought impacts on maize production in Zambia (Mwiinga *et al.*, 2016) ^[22]. Small-scale ponds, dams, and trenches allow farmers to store water for irrigation during dry periods. This ensures that maize crops receive adequate moisture during critical growth stages. Studies show yield increases of 15–25% for farmers who implement these systems. Training and technical guidance from extension

services enhance the efficiency and sustainability of rainwater harvesting. The method is labor-intensive and requires financial investment, which can limit adoption. Nonetheless, it provides a practical solution for drought-prone smallholder farmers.

Farmer field schools have been instrumental in improving the effectiveness of adaptive practices in Zambia (Chisanga *et al.*, 2017) ^[6]. Participants receive hands-on training in conservation agriculture, intercropping, and mulching techniques. Demonstration plots allow farmers to observe best practices and adapt them to local conditions. Studies indicate that field school participants achieve higher maize yields during drought years than non-participants. Knowledge sharing and peer learning increase the likelihood of correct adoption. Limited coverage of field schools remains a challenge for national-level impact. Overall, farmer education significantly enhances the effectiveness of adaptive strategies in maize farming.

Conservation agriculture has contributed to improved maize productivity in Zambia during dry seasons (FAO, 2018) ^[10]. Minimum tillage, crop rotation, and residue retention improve soil fertility and water retention. Farmers practicing conservation agriculture report yields that are more resilient to drought compared to conventional practices. Extension services and technical support are critical for correct adoption. Challenges include labor requirements for residue management and the availability of sufficient crop residues. Adoption rates increase when combined with drought-tolerant varieties and timely planting strategies. These findings show that conservation agriculture is a highly effective drought adaptation practice in Zambia.

Mobile-based climate information services have improved decision-making and maize yields in Zambia (Banda *et al.*, 2019) ^[3]. Farmers receive real-time weather forecasts, planting advice, and drought warnings via mobile phones. This allows timely planting, improved water management, and better selection of adaptive practices. Studies report maize yield increases of 10–15% among farmers using these services during drought years. Mobile services complement traditional extension programs and reach farmers in remote areas. Network coverage, literacy levels, and awareness affect adoption and effectiveness. Overall, mobile-based climate information significantly enhances the impact of adaptive strategies in Zambia.

2.4 Thematic area developed from objective three

Globally, farmer awareness and training have a direct impact on the adoption and sustainability of adaptive farming practices. Fisher *et al.* (2015) ^[13] found that structured training programs increased farmers' capacity to implement drought-tolerant maize cultivation and conservation agriculture effectively. Awareness campaigns combined with hands-on demonstrations significantly enhance farmers' understanding of climate-smart practices. Extension services provide guidance on appropriate planting times, input use, and soil management, reducing the risk of crop failure. Access to information also allows farmers to make timely decisions during periods of climate variability. Studies show that regions with well-developed extension systems experience higher adoption rates and better crop resilience (IFPRI, 2014) ^[15]. However, the effectiveness of training is often limited by inadequate resources and insufficient coverage in remote areas.

Early warning systems and climate information services

have strengthened global agricultural resilience by providing timely knowledge to farmers (IFPRI, 2014) ^[15]. Farmers receiving forecasts and advisories can adjust planting schedules and select drought-tolerant varieties more effectively. These services complement hands-on training and increase the precision of adaptive interventions. Fisher *et al.* (2015) ^[13] note that mobile technology has improved accessibility, allowing even remote farmers to benefit. Additionally, awareness of adaptive practices motivates farmers to adopt multiple complementary techniques simultaneously. However, technical literacy and trust in information sources influence how well these systems are used. Overall, awareness and timely information are critical in maximizing the effectiveness of adaptive strategies worldwide.

Farmer field schools (FFS) have emerged globally as effective tools for improving knowledge and skills (Tambo & Abdoulaye, 2013) ^[28]. Farmer field schools provide participatory learning platforms where farmers acquire practical knowledge through demonstration plots and peer learning. Studies indicate that farmers participating in FFS adopt adaptive practices more effectively than non-participants. Training also improves problem-solving skills, enabling farmers to adjust techniques based on local environmental conditions. Extension officers play a key role in linking scientific recommendations with traditional practices. Farmer Field Schools (FFS) have been shown to improve maize yields and reduce losses during drought events. Despite their success, limited funding and logistical challenges restrict the scalability of farmer field schools in many regions.

Institutional support, including access to credit, subsidies, and input supply, enhances farmers' capacity to implement adaptive strategies (World Bank, 2016) ^[32]. Financial resources enable smallholders to purchase drought-tolerant seeds, fertilizers, and irrigation equipment. Without such support, knowledge alone is often insufficient to promote effective adoption. Studies show that farmers with both training and financial backing achieve higher maize productivity under drought conditions. Additionally, government policies and non-governmental organisations (NGOs) programs that integrate training with input provision significantly improve sustainability. Access to markets for surplus produce also motivates farmers to adopt adaptive measures. This evidence demonstrates that awareness, training, and institutional support are mutually reinforcing in promoting resilience.

Global research emphasizes that knowledge dissemination alone is not enough; continuous support and follow-up are essential (FAO, 2021). Farmers require guidance on the practical application of techniques under varying climatic conditions. Monitoring and feedback mechanisms help identify challenges and improve intervention strategies. Awareness campaigns combined with ongoing extension services enhance farmers' confidence in adopting new methods. Multi-stakeholder collaboration, including NGOs, government agencies, and community leaders, strengthens support networks. Studies suggest that continuous engagement leads to higher adoption rates and long-term sustainability. Therefore, awareness, training, and institutional support are critical to ensuring that adaptive practices deliver intended results globally.

In Africa, farmer training and extension services are critical for adopting adaptive maize farming techniques. Deressa *et*

al. (2009) ^[9] observed that Ethiopian farmers who received regular training on drought-tolerant varieties and soil conservation techniques achieved higher maize yields during drought years. Training improves understanding of climate variability and teaches farmers how to combine multiple adaptive practices. Awareness programs, often delivered through local agricultural offices, help farmers make informed decisions regarding planting schedules and input use. Access to knowledge reduces the likelihood of crop failure and enhances resilience. Studies indicate that community engagement and participatory learning increase training effectiveness. However, inadequate coverage of extension services remains a challenge, particularly in remote rural areas.

In Kenya, Mude *et al.* (2012) ^[18] found that farmer field schools and training workshops significantly influenced the adoption of mulching, intercropping, and early planting techniques. Awareness of these methods increases confidence in their effectiveness, encouraging more farmers to experiment and adopt. The combination of technical training and peer-to-peer learning enhances practical understanding. Access to inputs such as seeds and organic mulches amplifies the benefits of training. Farmers report that training helps them anticipate drought conditions and select appropriate adaptation strategies. Lack of institutional support, however, limits adoption for poorer households. Thus, knowledge and awareness are essential for the effective application of adaptive practices.

Community-based adaptation programs in Malawi have highlighted the importance of training and awareness for collective drought resilience (Chinsinga, 2012) ^[5]. Farmers participating in seed banks, water management committees, and shared learning platforms gain critical skills to manage prolonged dry spells. These programs reduce individual risks and encourage adoption of best practices across the community. Studies indicate that maize yields are more stable in communities with high levels of awareness and training. NGOs and local governments often provide ongoing support and guidance, reinforcing learning outcomes. Institutional support ensures continuity and sustainability of adaptive practices. Without these services, adoption remains sporadic, and farmers' resilience is weakened.

In West Africa, Tambo and Abdoulaye (2013) ^[28] report that training in conservation agriculture and crop diversification directly improves the effectiveness of these practices. Farmers trained to manage residues, rotate crops, and select drought-tolerant varieties achieve higher maize yields. Awareness of the benefits of these strategies encourages sustained adoption. Microcredit and access to inputs further enhance the ability to implement techniques correctly. Studies indicate that well-informed farmers are more likely to combine multiple adaptive strategies, which increases resilience. Social structures and cooperative networks amplify the impact of training programs. Therefore, training, awareness, and institutional support are critical determinants of success in African maize farming.

Access to extension services and supportive institutions is crucial across Southern Africa (Nhemachena & Hassan, 2007) ^[24]. Farmers with regular training on drought-tolerant maize, inter-cropping, and mulching are more likely to adopt practices effectively. Credit facilities enable investment in inputs and small-scale irrigation, while market access motivates continued adoption. Studies show that

technical knowledge alone is insufficient without supportive institutions to provide resources and guidance. Awareness campaigns increase farmer participation and willingness to try new methods. Continuous training ensures proper implementation and enhances the long-term sustainability of adaptive practices. Collectively, these interventions illustrate the critical role of awareness, training, and support services in Africa.

In Zambia, farmer awareness and training have been shown to significantly influence the adoption and sustainability of adaptive practices (Tembo *et al.*, 2015) [30]. Training programs on drought-tolerant maize varieties, mulching, and early planting increase knowledge and improve crop management. Farmers who participate in training are more confident in implementing adaptive strategies correctly. Extension officers provide practical guidance on soil and water management, ensuring better maize productivity under drought. Lack of awareness often results in under-utilization of available interventions. Studies indicate that knowledge transfer enhances both short-term yields and long-term resilience. Overall, training is a key factor in successful adaptation in Zambia.

Rainwater harvesting initiatives have been more effective in communities where farmers receive technical guidance (Mwiinga *et al.*, 2016) [22]. Farmers trained on pond construction, water storage, and irrigation scheduling report higher maize yields. Awareness of proper maintenance reduces water loss and ensures sustained benefits over multiple seasons. Training programs also help farmers integrate rainwater harvesting with other practices, such as mulching and conservation agriculture. Studies indicate that effectiveness is lower in areas with poor awareness or limited extension support. Financial and technical support are critical for widespread adoption. Consequently, awareness and training are essential for maximizing the benefits of adaptive interventions.

Farmer field schools in Zambia have contributed significantly to the uptake and effectiveness of adaptive maize farming practices (Chisanga *et al.*, 2017) [6]. These schools provide experiential learning through demonstration plots, peer learning, and hands-on practice. Farmers who attend field schools adopt multiple adaptive strategies, resulting in more resilient maize production. Extension officers facilitate knowledge transfer and provide ongoing guidance. Studies indicate that FFS participants achieve higher yields during drought years compared to non-participants. However, limited coverage of schools means many smallholders remain unreached. Overall, field schools demonstrate that structured training and awareness programs enhance the effectiveness of adaptive practices.

Farmer Field Days (FFDs) are outreach and extension tools where farmers come together to view demonstrations, participate in discussions, and observe the performance of new practices under real farm conditions. Experimental evidence suggests that FFDs can significantly increase the adoption of new technologies by providing tangible information and peer validation. For example, field days have been shown to alleviate learning frictions and increase adoption rates for improved seeds by roughly 40% particularly among poorer farmers who benefit from direct observation and peer endorsement of innovations.

Conservation agriculture has been effective in Zambia where farmers receive training and support from extension services (FAO, 2018) [10]. Minimum tillage, crop rotation,

and residue retention improve soil fertility and moisture retention. Training ensures that farmers implement these techniques correctly, maximizing benefits during drought periods. Studies report yield increases and improved soil quality among trained farmers. Lack of guidance often leads to improper adoption and reduced effectiveness. Supportive institutions play a critical role in promoting these practices and providing necessary inputs. Awareness, training, and continuous follow-up thus enhance resilience to prolonged dry spells.

Mobile-based climate information services have improved maize productivity in Zambia by increasing farmer awareness and supporting timely decision-making (Banda *et al.*, 2019) [3]. Farmers receive real-time weather forecasts, drought alerts, and planting advice via mobile phones. Awareness of climate patterns enables farmers to implement adaptive practices such as early planting and irrigation effectively. Training on interpreting information ensures correct use of these services. Studies indicate that maize yields improve when mobile services are integrated with extension support and technical guidance. Adoption depends on network coverage, literacy, and farmer engagement. Overall, awareness, training, and institutional support amplify the impact of adaptive strategies in Zambian maize farming.

2.5 Personal Critique of the Literature

While existing literature provides a solid foundation on the types, effectiveness, and enabling conditions for adaptive farming, significant gaps remain. Most global and regional studies tend to generalize findings without considering the micro-level, socio-economic and ecological variations present in specific communities. In Zambia context, many studies focus on broader districts or provinces, overlooking localized realities like those in Demu Ward of Pemba District.

Additionally, while the positive impact of adaptive farming on yields is well-documented, the long-term sustainability and cost-benefit trade-offs of these practices are under-explored. Little attention is paid to the behavioral and institutional factors that affect adoption, such as cultural norms, land tenure, and household decision-making dynamics.

2.6 Establishing Gaps in the Literature Review

Globally, the literature on adaptive farming practices largely focuses on the technical effectiveness of interventions, such as drought-tolerant maize, conservation agriculture, and irrigation techniques (Rippke *et al.*, 2016; Daryanto *et al.*, 2016 [8]). While these studies report yield improvements under drought, there is limited research on the socio-economic and behavioral factors that influence adoption at the household level. Few studies examine how farmers' perceptions, cultural norms, and risk preferences affect their willingness to implement adaptive practices. Additionally, most global studies emphasize short-term outcomes, neglecting the long-term sustainability and resilience of these interventions. This highlights a need for research that integrates technical, social, and economic dimensions to understand adoption patterns comprehensively.

At the African level, research has highlighted successful adaptive practices, such as mulching, inter-cropping, and community-based water management (Deressa *et al.*, 2009; Tambo & Abdoulaye, 2013) [9, 28]. However, there are gaps

in understanding how local institutional support, extension services, and access to financial resources shape the effectiveness and scalability of these interventions. Many studies focus on case-specific regions, limiting the generalizability of findings across diverse agro-ecological zones. Moreover, there is insufficient investigation into the barriers faced by smallholder farmers in adopting multiple adaptive practices simultaneously. This indicates a need for research that examines the interaction between institutional support, knowledge dissemination, and adaptive capacity at the community level.

In Zambia, although several studies have assessed the adoption of drought-tolerant maize, conservation agriculture, and rainwater harvesting (Tembo *et al.*, 2015; Chisanga *et al.*, 2017) [30, 6], research gaps remain regarding the effectiveness of these practices under prolonged drought conditions specific to local wards like Demu. Most studies emphasize technical adoption rather than evaluating how farmer awareness, training, and support services influence outcomes. Additionally, limited research exists on how socio-economic constraints, such as access to inputs, credit, and labor, affect the sustainability of adaptive practices. There is also a paucity of longitudinal studies that monitor the long-term impact of these interventions on maize productivity and household food security.

Finally, across all levels, there is a gap in understanding the contextualized integration of multiple adaptive practices, including drought-tolerant varieties, conservation agriculture, irrigation, and agroforestry. While individual practices have been studied extensively, few studies explore how combinations of practices interact to enhance resilience, particularly under prolonged drought. Furthermore, limited research examines local perceptions, knowledge-sharing mechanisms, and cultural influences on adoption, especially in rural communities with unique agro-ecological and socio-economic conditions. Addressing these gaps is critical for designing more effective, scalable, and context-specific interventions that improve maize production under drought conditions.

3. Methodology

3.1 Overview

This chapter outlines the methodological framework that guided the study on the effectiveness of adaptive farming practices in mitigating the effects of prolonged droughts on maize production in Demu Ward of Pemba District. It provides a comprehensive explanation of the research design, target population, sampling strategy, sample size, data collection instruments, and data analysis techniques used. Additionally, the chapter discusses the use of triangulation to enhance validity, highlights the study's limitations, and presents the ethical considerations adhered to during the research process.

3.2 Research Design

This study adopts a mixed-methods research design, combining both quantitative and qualitative approaches to provide a comprehensive understanding of adaptive farming practices in Demu Ward. The quantitative component focuses on collecting numerical data, such as maize yield levels, farm sizes, types of adaptive techniques used, and demographic characteristics of farmers. This approach allows for statistical analysis to determine patterns, relationships, and correlations between different adaptive

practices and maize productivity. For instance, it can show whether farmers who practice mulching achieve higher yields than those who rely solely on traditional methods.

The qualitative component complements the quantitative data by exploring farmers' experiences, perceptions, and knowledge regarding adaptive techniques. Semi-structured interviews, focus group discussions, and observations will capture contextual insights that numbers alone cannot provide. Through these methods, the study can investigate why some farmers adopt multiple adaptive strategies while others resist change. It also examines social and cultural factors influencing adoption, such as traditional knowledge, peer influence, and risk perception.

Adopting a mixed-methods design is particularly suitable for agricultural research in complex rural environments. Creswell (2014) [7] emphasizes that this design integrates statistical trends with in-depth, context-specific understanding, enhancing both validity and reliability. By triangulating quantitative results with qualitative narratives, the study provides a nuanced picture of the effectiveness of adaptive practices. Moreover, it allows policymakers and extension officers to understand not only what works technically but also the socio-economic and institutional factors influencing success. Ultimately, this design ensures a holistic approach to addressing the challenges posed by prolonged droughts on maize production.

3.3 Target Population

The primary target population for this study consists of smallholder maize farmers in Demu Ward of Pemba District. These farmers are central to the research because they are most affected by drought and directly engage in maize production, which is a staple crop in Zambia. Understanding their experiences, challenges, and adaptive practices provides crucial insight into resilience strategies that are locally relevant. The study prioritizes farmers who have attempted at least one adaptive practice, ensuring that respondents have practical exposure to techniques being analyzed.

Agricultural extension officers are another critical segment of the target population. These officers play a pivotal role in facilitating training, providing inputs, and advising farmers on climate-smart agricultural practices. Their perspectives shed light on the effectiveness of institutional support, challenges in promoting adaptive techniques, and gaps in current training programs. Extension officers' insights also help understand the alignment between government policy, NGO interventions, and community needs.

Finally, community leaders are included to capture the broader socio-cultural and organizational context of maize farming in Demu Ward. Leaders often mobilize resources, mediate disputes, and influence farmers' decisions regarding agricultural practices. They provide information on community-level adoption patterns, barriers, and successes of adaptive strategies. Collectively, these three groups ensure the study captures a comprehensive view of both technical and socio-institutional dimensions affecting adaptive farming practices.

3.4 Sampling Design

A purposive sampling technique will be employed to select respondents with practical experience in adaptive farming. This ensures that only those with firsthand knowledge of practices such as conservation tillage, early-maturing seeds,

mulching, or water harvesting contribute to the study. Purposive sampling is particularly effective in rural contexts where farm-level expertise is unevenly distributed, allowing researchers to target individuals who can provide rich and relevant data.

To reach additional experienced farmers, snowball sampling will be used. Initial respondents will refer other knowledgeable farmers, creating a chain of referrals that helps identify participants who might otherwise be overlooked. This approach is useful in rural areas where formal records of adaptive practice adoption are limited. It also increases trust between researchers and participants, as referrals come from known community members.

The combination of purposive and snowball sampling ensures diversity while maintaining focus on relevant respondents. By targeting experienced farmers, the study increases the likelihood of gathering reliable data on the practical application and outcomes of adaptive practices. Additionally, it ensures representation across age, gender, and farm size, capturing the experiences of a wide cross-section of the farming community. This approach balances efficiency, relevance, and inclusivity in the sampling process.

3.5 Sample Size Determination

The study will engage 60 smallholder maize farmers from 3 agriculture camps under Demu Ward, namely: Lombwa camp with 504 registered farmers, Demu camp with 1630 registered farmers, and Bulanda camp with 1198 registered farmers. 20 respondents will be picked from each camp representing a sufficiently large sample to provide reliable quantitative data while allowing for in-depth qualitative exploration. This sample ensures representation across various demographic characteristics, including gender, age, and farm size, which can influence adoption of adaptive practices. A sample of this size aligns with best practices for mixed-methods research, allowing for meaningful statistical analysis and thematic saturation in qualitative findings (Guest, Bunce & Johnson, 2006) ^[14].

In addition to farmers, five key informants will be selected for in-depth interviews. These include agricultural extension officers, camp officers, and community development officers. Their perspectives provide valuable institutional insight into the training, support, and challenges associated with promoting adaptive farming practices.

The sample size strikes is selected to achieve a balance between practical manageability and statistical representativeness. It ensures that both individual-level experiences and institutional perspectives are captured. Additionally, the sample is practical for fieldwork logistics, allowing researchers to conduct comprehensive interviews, focus groups, and observations within a reasonable timeframe. This approach enhances the reliability and validity of the study findings.

3.6 Data Collection Methods

The study will employ multiple data collection methods to ensure reliability and richness. Structured questionnaires will collect quantitative data on farm size, maize yields, adoption of adaptive practices, and exposure to training programs. This allows the study to quantify trends and relationships between variables and provides a baseline for statistical analysis.

Semi-structured interviews with key informants, such as

extension officers and community leaders, will explore institutional perspectives, challenges, and success stories. These interviews capture nuanced information on support mechanisms, barriers to adoption, and perceptions of adaptive practices.

Focus group discussions (FGDs), comprising 6–8 farmers per group, will facilitate interactive discussions, allowing participants to share experiences, highlight challenges, and propose solutions. Direct field observations will verify actual practices and assess farm conditions, ensuring that reported techniques align with observed realities. Pre-testing all instruments ensures clarity, cultural appropriateness, and relevance. By combining these methods, the study captures both quantitative outcomes and qualitative insights, enhancing overall data robustness.

3.7 Data Analysis

Quantitative data will be analyzed using SPSS/Excel software. Descriptive statistics such as means, frequencies, and percentages will summarize farmer demographics, maize yields, and adoption patterns. Inferential statistics, including Pearson correlation and regression analysis, will determine the relationship between adaptive practices and maize yield levels.

Qualitative data from interviews and focus group discussion (FGDs) will be transcribed and analyzed thematically (Braun & Clarke, 2006) ^[4]. Coding will identify recurring patterns and categorize emerging themes, allowing the study to explore farmer perceptions, institutional support, and socio-cultural influences on adoption.

Integrating quantitative and qualitative findings allows the study to corroborate numerical trends with contextual experiences. For example, a correlation between mulching and higher yields can be interpreted alongside farmers' explanations of challenges, costs, and labor involved. This combination ensures a nuanced understanding of both effectiveness and sustainability of adaptive practices in the study area.

3.8 Triangulation

Triangulation enhances the credibility, reliability, and validity of findings. Methodological triangulation involves using multiple data collection methods questionnaires, interviews, focus group discussions, and observations to cross-check findings. This reduces bias arising from reliance on a single method.

Data source triangulation collects information from diverse participants, including farmers, extension officers, and community leaders. Comparing these perspectives allows verification of information and highlights consistencies or discrepancies in reported practices and outcomes.

Triangulation also ensures that quantitative and qualitative data complement each other. For instance, statistical trends in maize yield can be interpreted alongside farmers' explanations of adaptive techniques and institutional challenges. This multi-dimensional approach strengthens confidence in findings and provides a comprehensive understanding of adaptive farming practices under drought conditions.

3.9 Limitations of the Study

One limitation is weather dependency, as data collection could be delayed by heavy rainfall, extreme heat, or prolonged dry spells, affecting farm visits and observational

schedules. Field conditions may also limit access to certain farms. Recall bias is another concern, as farmers may inaccurately remember past yields, drought years, or adaptive practices implemented. Self-reported data could be affected by memory errors or exaggeration. Limited official records at the ward level may also challenge data verification, particularly for historical yield and intervention data.

Language barriers may affect communication during interviews and focus group discussions. While translators will assist, technical concepts or nuanced responses may lose depth or clarity. To minimize these limitations, triangulation of data, cross-validation from multiple sources, and engagement of local enumerators familiar with the community and language will be employed.

3.10 Ethical Considerations

Ethical considerations are fundamental to conducting research involving human participants. This study will adhere strictly to recognized ethical standards throughout the research process to ensure that the rights, dignity, and welfare of participants are protected. Ethical approval will be obtained from both academic review boards and relevant local authorities in Pemba District before fieldwork begins. This step ensures that the study design, data collection methods, and consent procedures meet formal ethical requirements and are culturally appropriate.

Informed consent will be a key principle guiding the engagement of participants. All respondents, including smallholder farmers, agricultural extension officers, and community leaders, will be fully informed about the purpose of the study, the procedures to be followed, the voluntary nature of participation, and the potential benefits and risks involved. Participants will be given the opportunity to ask questions and will be required to provide written or verbal consent before participating. This process ensures that participation is entirely voluntary and based on a clear understanding of the study.

Confidentiality and anonymity will be strictly maintained to protect participant privacy. Personal identifiers such as names, addresses, and contact information will not be disclosed in any reports or publications. Data will be coded and stored securely in password-protected files and locked cabinets accessible only to the research team. This safeguards sensitive information and reduces the risk of unintended disclosure, fostering trust between participants and researchers.

The study will also prioritize cultural sensitivity and respect for local norms and practices. Data collection methods, such as interviews and focus group discussions, will be conducted in local languages where necessary, with the assistance of trained interpreters to ensure accurate communication. Researchers will respect local customs, hierarchical structures, and community protocols, ensuring that the research does not disrupt social cohesion or offend cultural values. This approach also enhances participation and cooperation from the community.

Finally, the research will adhere to broader ethical principles such as non-maleficence and beneficence, ensuring that no harm comes to participants and that the study has potential benefits for the community. Care will be taken to avoid psychological distress, exploitation, or undue burden during data collection. The findings of the study are intended to inform policy and practice, helping to improve maize

production and adaptive strategies in drought-prone areas, thereby contributing positively to the welfare of participants and their communities. Ethical compliance throughout the study enhances the credibility, integrity, and social value of the research.

4. Presentation and Discussion of Findings

4.1 Overview

This chapter presents the findings from the study on adaptive farming practices used by smallholder maize farmers during drought periods. Data were collected from a sample of 60 respondents. Quantitative results are presented in tables preceded by interpretive discussions, while qualitative responses from open-ended questions are summarized with illustrative quotes. The discussion links findings to existing literature, highlighting consistencies, variations, and implications for drought resilience in maize farming.

4.2 Background characteristics of the respondents

In order to understand the effectiveness of adaptive farming practices in mitigating the effects of prolonged drought on maize production in Demu ward of Pemba district, it is crucial to first examine the demographic profile of the respondents and the affected communities. This section presents key demographic findings; population size, and density, age distribution, gender, household characteristics, education levels, farming experience and location. These characteristics provide context for understanding the ways in which adaptive farming practices may succeed or be constrained.

To present the farmer population size, density, and spatial distribution of Demu Ward in Pemba District in a clear and professional table format.

Table 1: Farmer Population and spatial characteristics of Demu Ward in Pemba District (2025 farmer registration - DACO office Ministry of Agriculture - Pemba) by 60 respondents

Characteristics	Category	Frequency %	Estimated # of Respondents
Gender	Male	65%	39
	Female	35%	21
Age Group	35 years and below	65%	39
	36 years and above	35%	21
Education level	Primary education	35%	21
	Higher Education	40%	24
	Tertiary Education	20%	12
	No formal Education	5%	3
Farming Experience	Less than 5 years	15%	9
	10 years	45%	27
	20 years and above	40%	24

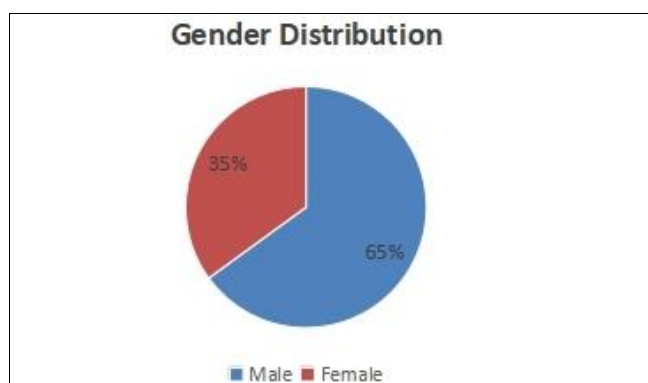
The study involved 60 registered farmers drawn from three strata (20) each agricultural camps within Demu ward, namely Lombwa (504), Demu (1630), and Bulanda, proportional of their population sizes.

The background characteristics of respondents in Demu Ward provide valuable insights into the socio-economic and demographic factors that shape their ability to adapt to climate variability - particularly prolonged droughts that threaten maize production. Understanding these characteristics helps to determine the adaptive capacity, decision-making behavior, and the overall resilience of farming households.

4.2.1 Gender Distribution

The data indicate that 65% of respondents are male, while 35% are female. This shows that men dominate farming activities in Demu Ward, which is consistent with the general pattern in most rural Zambian communities where men own or manage most of the land. However, the significant proportion of women (35%) suggests that women also play an active role in agriculture, either as co-farmers or household heads.

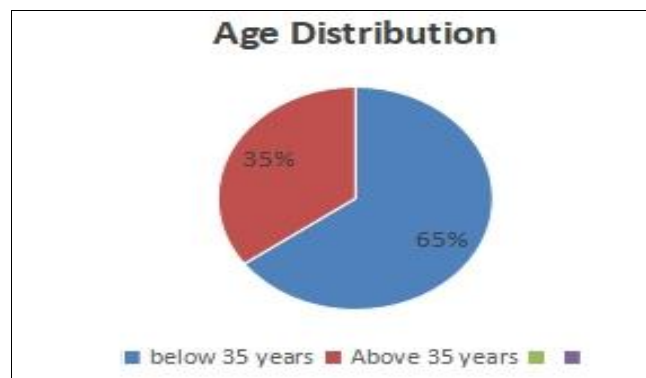
This gender balance has implications for adaptive farming practices. Men often have greater access to resources such as land, capital, and extension services, which can enhance their ability to implement drought mitigation measures such as conservation farming, irrigation, and use of drought-tolerant maize varieties. On the other hand, empowering women through training and access to inputs can increase household resilience, since women tend to prioritize food security and sustainable farming practices. Therefore, gender-inclusive agricultural policies are essential for improving adaptive capacity.



4.2.2 Age Distribution

A majority (65%) of respondents are 35 years and below, while 35% are above 36 years. This indicates a relatively young farming population, which is promising for innovation and adoption of modern farming techniques. Younger farmers are generally more receptive to new technologies such as e-governance platforms, climate-smart agriculture, and mobile-based weather information services. Their energy and willingness to experiment with new methods can help in the adoption of drought-mitigation strategies like early planting, water-harvesting systems, and conservation tillage. However, younger farmers may lack sufficient experience and capital, making targeted training programs and access to finance crucial for building their resilience.

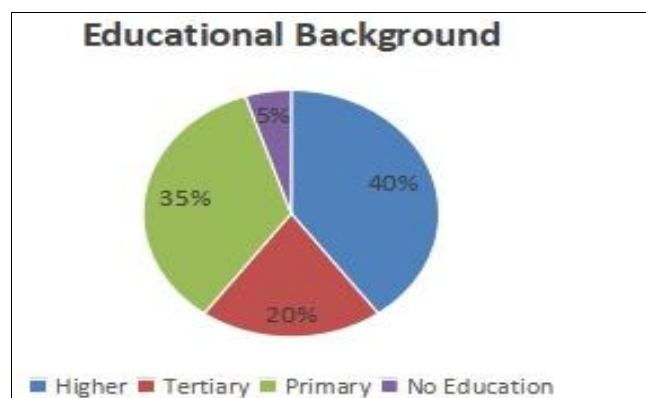
Older farmers, though fewer in number, bring valuable experience and indigenous knowledge about traditional coping mechanisms such as crop rotation and intercropping. Combining this experience with the energy and technological openness of the youth could significantly enhance community-wide drought adaptation in Demu Ward.



4.2.3 Education Background

Educational attainment among respondents is relatively high, with 40% having completed higher education, 35% with primary education, 20% with tertiary education, and only 5% with no formal education. This shows that a majority of farmers have attained some level of literacy, which is beneficial for information access and utilization. Farmers with higher and tertiary education levels are more likely to understand and apply scientific information on soil management, irrigation scheduling, and use of improved seed varieties. They can also interpret early warning systems and weather forecasts, thereby improving decision-making during prolonged droughts.

Meanwhile, farmers with lower education levels may depend more on traditional knowledge, which, although useful, might limit their participation in modern adaptive technologies. Hence, extension officers should design training programs that are simple, practical, and easily understood by all educational levels to promote inclusive adaptation.

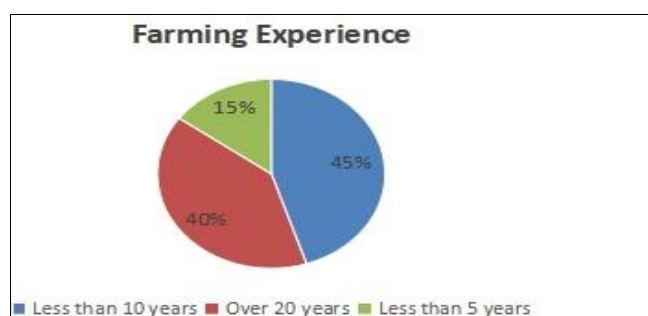


4.2.4 Farming Experience

The distribution of farming experience reveals that 45% of respondents have at least 10 years of experience, 40% have over 20 years, and 15% have less than 5 years. This pattern indicates a strong base of experienced farmers who possess deep knowledge of local climatic patterns and traditional coping strategies. Farmers with over 20 years of experience have likely witnessed multiple drought cycles and developed

indigenous adaptation measures such as mixed cropping, crop diversification, and soil moisture conservation. Such experience is crucial in guiding the younger farmers and strengthening community-level adaptation.

However, those with less than 5 years of experience may lack exposure to climate variability and may struggle to make effective adaptive decisions. Strengthening farmer-to-farmer extension programs and mentorship between experienced and newer farmers could enhance knowledge transfer and overall resilience in Demu Ward. The combined effect of the respondents' characteristics suggests that Demu Ward has moderate to high adaptive potential. The youthful population and fairly educated farmers provide an excellent foundation for adopting climate-smart technologies. The experienced farmers serve as local reservoirs of indigenous knowledge, while gender inclusion offers opportunities for household-level diversification of strategies.



4.2.5 Farm Size

The findings indicate that 30 respondents (50%) cultivate between 1 and 2 hectares, 18 respondents (30%) cultivate less than 1 hectare, 9 respondents (15%) cultivate between 3 and 5 hectares, and only 3 respondents (5%) cultivate over 5 hectares. This distribution reflects that maize farming in the study area is predominantly smallholder in scale. Small farm sizes often limit the scope of operations, making it challenging to implement resource-intensive adaptive practices such as large-scale irrigation systems or mechanized conservation farming. The predominance of smallholder farms underscores the need for context-specific adaptive strategies that are feasible, cost-effective, and tailored to limited land resources.

Smallholder farmers often face constraints related to capital, agricultural inputs, and access to equipment, which can affect both the selection and effectiveness of adaptive farming practices. According to FAO (2018) [10], these limitations are common across sub-Saharan Africa, where smallholders must prioritize low-cost, labor-efficient techniques that maximize yield without requiring substantial investment. The reliance on limited resources can influence the type of adaptive strategies adopted, with farmers often opting for interventions that provide immediate benefits under drought conditions. Such strategies are typically designed to optimize land productivity while conserving soil moisture and maintaining soil fertility.

Despite these constraints, smallholder farmers demonstrate remarkable flexibility and innovation in managing their farms under drought stress. Techniques such as mulching, early planting, crop rotation, and the use of drought-resistant maize varieties are widely employed because they are labor- and cost-efficient, yet highly effective in mitigating the impacts of drought. These strategies enable farmers to maintain or even increase yields without the need for

significant capital investment. The ability of smallholders to adapt in such a context highlights their resilience and ingenuity, emphasizing the importance of supporting these farmers with technical knowledge, inputs, and targeted interventions to enhance productivity and sustainability under challenging climatic conditions.

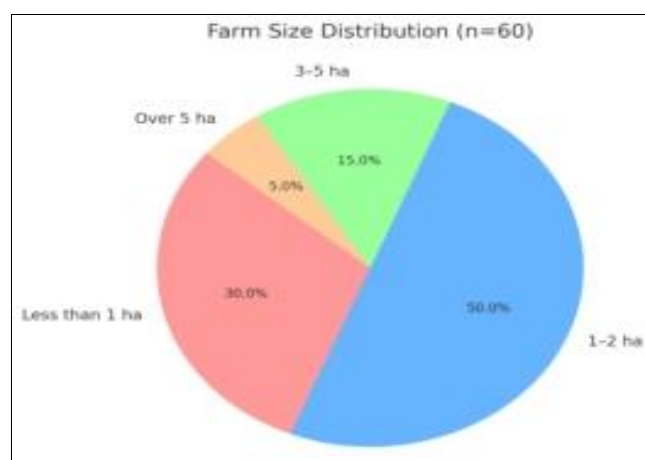


Fig 1: Farm Size (Hectares) (n=60)

The results show that the majority of farmers in the study area operate on small pieces of land, with 50% cultivating between 1 and 2 hectares and 30% cultivating less than 1 hectare. This means that 80% of the respondents are small-scale farmers who rely mainly on family labor and limited resources. Only a small proportion, 20%, cultivate more than 3 hectares, indicating that large-scale or commercial maize farming is rare in the area. The dominance of smallholder farmers suggests that most agricultural activities are subsistence-based, focused on meeting household food needs rather than producing for large markets.

Because of their limited land size and capital, these smallholders often face challenges in adopting expensive or resource-demanding adaptive practices such as irrigation or mechanized farming. Instead, they tend to implement low-cost, labor-based methods like mulching, early planting, crop rotation, and using drought-resistant maize varieties. These approaches are practical and effective for conserving soil moisture and improving yields under drought conditions.

Overall, the results highlight that smallholder farmers play a vital role in maize production despite their limited resources. Their resilience and creativity in adopting affordable, sustainable adaptive practices demonstrate the potential for improving productivity if they are supported with proper training, access to inputs, and technical guidance from agricultural extension services.

4.3 Presentation of results based on a thematic are developed from objective one

Adaptive farming practices refer to agricultural techniques and innovations that enable farmers to adjust to and mitigate the adverse effects of climate variability and change. These practices enhance resilience, conserve natural resources, and ensure food security through improved productivity and sustainability.

Globally, adaptive farming practices have become a cornerstone of sustainable agricultural development. The Intergovernmental Panel on Climate Change (IPCC, 2023) emphasizes the role of conservation agriculture,

agroforestry, crop diversification, and water-efficient technologies as crucial in minimizing vulnerability to climate change.

In countries such as Brazil, India, and Kenya, conservation farming and agroforestry systems have been instrumental in maintaining soil fertility, preventing erosion, and improving moisture retention. Similarly, mulching and crop rotation are widely promoted under the United Nations' Sustainable Development Goal (SDG) 13, which calls for urgent action to combat climate change and its impacts. Globally, the adoption of these practices is influenced by policy support, access to extension services, and climate adaptation funding mechanisms.

Across Sub-Saharan Africa, the impacts of climate change — including prolonged droughts, unpredictable rainfall, and declining soil fertility — have accelerated the adoption of adaptive farming practices. Countries such as Ethiopia, Malawi, and Zimbabwe have implemented national adaptation programs that promote conservation farming and water harvesting to strengthen smallholder resilience. In Southern Africa, particularly under the Southern African Development Community (SADC) framework, member states have adopted Climate Smart Agriculture (CSA) approaches that integrate conservation tillage, agroforestry, mulching, and efficient water-use systems. Studies indicate that farmers using these methods have reported higher yields, reduced soil degradation, and increased food security despite erratic weather conditions.

However, the uptake of adaptive practices across the region remains uneven due to factors such as limited financial resources, lack of awareness, and inadequate access to agricultural technologies. Nonetheless, regional programs such as the Comprehensive Africa Agriculture Development Programme (CAADP) and FAO-supported initiatives continue to strengthen farmer capacity and resilience.

In Zambia, agriculture remains the backbone of rural livelihoods, with smallholder farmers contributing over 70% of national food production. The government, through the Ministry of Agriculture, has promoted adaptive practices under the National Agricultural Policy and Zambia's Climate Change Response Strategy (2016–2030). Key practices encouraged include conservation farming, crop diversification, and the use of drought-resistant varieties.

Within Southern Province, climate variability — particularly droughts and dry spells — has significantly affected productivity. Consequently, adaptive farming has become a vital response mechanism. Pemba District, being semi-arid, faces frequent rainfall shortages, necessitating methods such as water harvesting, mulching, and conservation agriculture. Findings from the field survey conducted in Demu Ward, which forms part of Pemba District, revealed that farmers are increasingly embracing adaptive farming methods to cope with changing weather patterns.

The distribution of the adaptive practices among respondents is shown below:

Adaptive Farming Practice	(%)
Conservation Farming	20.0
Mulching	13.8
Crop Rotation	10.8
Water Harvesting	9.2
Agroforestry	7.7
Others	3.1

Interpretation of Findings

The data indicate that conservation farming (20%) is the most widely adopted adaptive practice among farmers in Demu Ward. This finding aligns with national agricultural programs that have promoted minimal tillage and residue retention as key conservation techniques. Farmers acknowledge that this practice helps conserve moisture, reduce soil erosion, and improve productivity.

Mulching (13.8%) ranks second, as farmers use crop residues and grass to retain soil moisture and suppress weeds. Crop rotation (10.8%) is also notable, as it aids in improving soil fertility and reducing pest infestations. Water harvesting (9.2%), though less practiced, plays an essential role in ensuring water availability during dry periods through the construction of small reservoirs and ridges. Agroforestry (7.7%), involving the integration of trees with crops, contributes to soil enrichment and microclimate stabilization.

The “Others” category (3.1%) includes practices such as composting and organic manure application, which complement the more dominant methods. Despite their relatively low uptake, these practices contribute significantly to sustainability and soil fertility management.

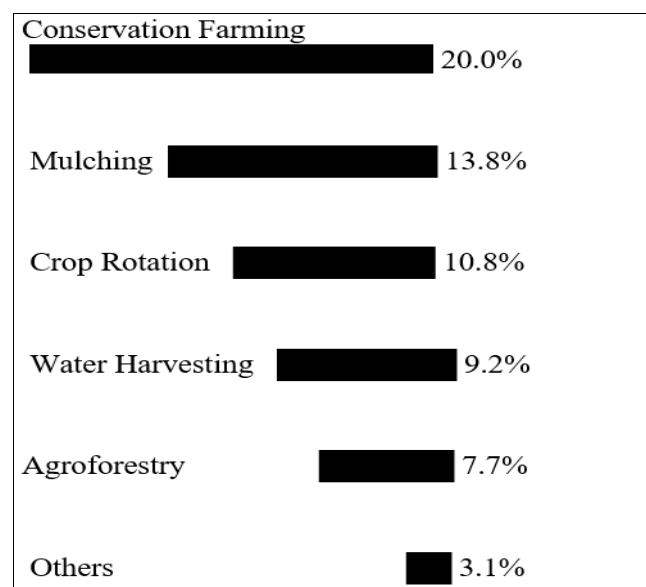


Fig 2: Adaptive Farming Practices in Demu Ward, Pemba District

4.3.1 Discussion of the Findings

The results underscore the importance of conservation farming as the leading adaptive strategy among smallholder farmers in Demu Ward. The higher adoption rate can be attributed to continued sensitization by agricultural extension officers, NGOs, and government programs such as the Conservation Farming Unit (CFU).

The moderate adoption of mulching, crop rotation, and water harvesting reflects a growing awareness of sustainable soil and water management, though the practices remain constrained by limited access to technical knowledge and resources. The relatively low uptake of agroforestry and other organic methods indicates the need for enhanced training, seedling availability, and integration of local knowledge systems.

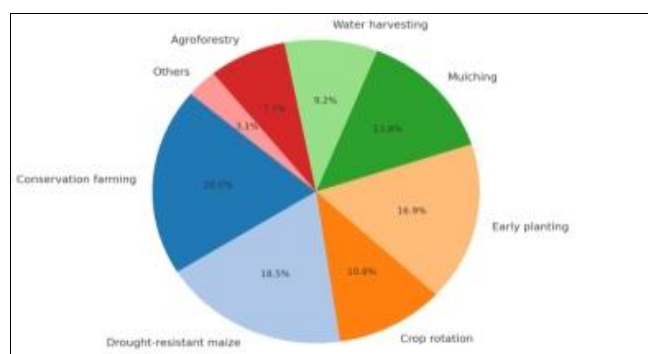
Overall, the findings suggest that while farmers in Demu Ward have begun adopting adaptive farming practices, there remains a need for stronger institutional support, climate

information services, and access to inputs to enhance resilience and productivity.

From the global to the local scale, adaptive farming practices form the cornerstone of resilience against climate change. In Demu Ward, farmers have demonstrated awareness and participation in such practices, particularly conservation farming and mulching. Strengthening local capacity through extension services, demonstration plots, and farmer cooperatives will be vital in scaling up adoption. The findings provide a basis for policymakers and agricultural planners to develop targeted interventions aimed at promoting sustainable and climate-resilient farming systems in Pemba District and beyond.

Table 2: Adaptive Farming Practices Used During Droughts
(n=60)

S. No	Adaptive Farming Practice	Adoption %
1	Conservation Farming	20
2	Drought Resistant maize seeds	18.5
3	Crop rotation	10.8
4	Early planting	16.9
5	mulching	13.8
6	Water harvest	9.2
7	Agro forestry	7.7
8	others	3.1



4.3.2 Below are qualitative results related to the above quantitative results

Respondents reported that the main reason for adopting adaptive practices was to improve resilience against drought, maintain or increase crop yields, and preserve soil moisture. These motivations reflect the direct challenges farmers face in their daily agricultural activities and the need for practical solutions. By focusing on these outcomes, farmers demonstrated an awareness of how adaptive strategies could safeguard their livelihoods in both stable and uncertain seasons.

Many farmers also emphasized that their decisions were strongly shaped by personal experience and the observed effectiveness of these practices in previous farming seasons. When farmers saw positive results in their own fields, it strengthened their confidence in continuing with the same methods. This reliance on firsthand experience highlights the role of trial and observation as powerful motivators for change, often outweighing abstract recommendations from external sources.

The findings therefore reveal that adoption is not solely dependent on advice from extension officers, NGOs, or training programs, but also on farmers' ability to critically assess what works best for them. Their practical mindset enables them to evaluate immediate benefits such as yield stability, while also considering long-term outcomes like

soil fertility and sustainability. This supports earlier research which argues that experiential learning and observed success are central to encouraging innovation among farmers (Meijer *et al.*, 2015, p. 37).

4.3.3 Sources of Knowledge

The findings indicate that extension officers are the primary source of agricultural information for most respondents, with 50% relying on them. This suggests that government or institutional agricultural extension services play a crucial role in knowledge dissemination among farmers. Fellow farmers are also a significant source at 40%, showing the importance of peer learning and experience sharing within farming communities. NGO programs (35%) and training/workshops (25%) also contribute meaningfully, reflecting the impact of development initiatives and capacity-building efforts. Meanwhile, radio/TV (20%) serve as important but less dominant mass media sources, and only a small portion (5%) rely on other unspecified sources. Overall, the data highlights that interpersonal and institutional channels are the most influential in delivering agricultural information to farmers.

Table 3: Sources of Knowledge About adaptive farming Practices
(n=60)

Source	Frequency	Percentage
Extension officer	30	50%
Fellow farmers	24	40%
NGO programs	21	35%
Training/workshops	15	25%
Radio/TV	12	20%
Other	3	5%

4.4 Presentation of results based on a thematic area developed from objective two

The effectiveness of adaptive practices was assessed using three key measures: farmers' perceived effectiveness, estimated differences in maize yields with and without adaptive practices, and their intention to continue using these practices in future drought seasons. The findings indicate that most farmers perceive the adopted strategies as beneficial, demonstrating confidence in techniques such as conservation farming, drought-resistant maize varieties, early planting, mulching, and crop rotation. This positive perception reflects both the practical experience of farmers and their observation of improved crop performance during periods of water scarcity, suggesting that these practices contribute significantly to drought resilience.

In terms of yield differences, farmers reported noticeable improvements when employing adaptive strategies. On average, maize yields increased from 20–30 bags (1–1.5 tons) per hectare without adaptive practices to 80–120 bags (4–5 tons) per hectare with the use of adaptive farming practices in combination with good crop management. These findings suggest that adaptive practices can enhance productivity, even under adverse climatic conditions. Variations in perceived and actual effectiveness were observed, often linked to factors such as farm size, level of education, access to inputs, farming experience, and correct implementation of techniques. Farmers with larger plots, higher education, and greater experience tended to report higher effectiveness, highlighting the influence of socio-economic and farm-related variables on the outcomes of adaptive strategies.

The majority of farmers also indicated a strong intention to continue using adaptive practices in future drought seasons,

reflecting their recognition of long-term benefits such as improved yield stability, soil conservation, and enhanced food security. However, some farmers expressed uncertainty or dissatisfaction due to constraints such as limited access to drought-resistant seeds, insufficient technical guidance, or labor-intensive requirements of certain practices like agroforestry and water harvesting. These findings underscore the importance of providing adequate support services, including timely input provision, continuous training, and extension guidance, to ensure that adaptive strategies remain effective, sustainable, and widely adopted across diverse farming contexts.

“Most farmers perceive the adopted strategies as beneficial, demonstrating confidence in techniques such as conservation farming, drought-resistant maize varieties, early planting, mulching, and crop rotation.”

Table 4: Perceived Effectiveness of Adaptive farming Practices (n=60)

Effectiveness Level	Frequency	Percentage
Very effective	27	45%
Moderately effective	24	40%
Not effective	9	15%
Total	60	100%

Interpretation: Table 4: shows that 85% of respondents found adaptive practices either very effective or moderately effective, demonstrating that these strategies positively influence maize productivity during drought conditions. Farmers who rated practices as very effective often employed multiple strategies simultaneously, such as combining conservation farming with drought-resistant maize varieties. This supports findings by Ngoma *et al.* (2020), who argue that integrated adaptive approaches create synergistic benefits, improving soil moisture retention, nutrient cycling, and plant resilience. Conversely, farmers who found practices less effective cited challenges such as inadequate access to inputs, limited knowledge, and labor constraints. The 15% reporting ineffectiveness underscores the importance of tailored extension services and continuous farmer education to ensure optimal implementation of adaptive strategies.

Table 5: Estimated Yield Differences With and Without Adaptive Practices (Bags/ha)

Adaptive Practices Use	Average Yield (bags/ha)
Without adaptive practices	20-30
With adaptive practices	80-120

Interpretation: Table 5: indicates that farmers observed a yield increase of 20-30 bags per hectare when employing adaptive practices. This quantitative improvement reflects the real-world benefits of strategies such as early planting, mulching, and drought-tolerant maize. Deressa *et al.* (2011) note that yield improvements under drought conditions are often linked to farmers' ability to combine both traditional knowledge and modern innovations. Moreover, the adoption of such practices contributes to food security and income stability, particularly for smallholder farmers who are highly vulnerable to climate variability. The variability in yields also reflects differences in soil fertility, farm size, rainfall patterns, and farmers' skill in implementing techniques correctly.

Table 6: Intention to Continue Using Adaptive Practices (n=60)

Response	Frequency	Percentage
Yes	51	85%
No	3	5%
Not sure	6	10%
Total	60	100%

Interpretation: Table 6: shows that the majority of respondents (85%) intend to continue using adaptive practices in future drought seasons. This high continuation rate indicates farmers' recognition of the long-term benefits of strategies that enhance soil conservation, yield stability, and resilience to climate shocks. Meijer *et al.* (2015) emphasize that sustained adoption is critical for building adaptive capacity in farming communities. The minority who are unsure or unwilling to continue may face challenges such as insufficient input supply, labor shortages, or skepticism about the long-term effectiveness of certain practices. These findings highlight the need for continuous monitoring, farmer support, and policy interventions to ensure consistent adoption and scaling of successful adaptive strategies.

4.5 Presentation of results on a thematic area developed from objective three

Farmer support services are critical in promoting the adoption and effective use of adaptive practices. Respondents highlighted the role of extension officers, NGOs, training workshops, and peer learning in providing technical advice, inputs, and practical demonstrations. The availability and accessibility of these services influence both the effectiveness and sustainability of adaptive strategies.

Table 7: Access to Farmer Support Services (n=60)

Support Service	Frequency	Percentage
Extension officers	30	50%
NGO programs	21	35%
Training/workshops	15	25%
Radio/TV programs	12	20%
Peer learning (fellow farmers)	24	40%
Other	3	5%

Interpretation Table 7: Highlights that extension officers were the most accessed support service, assisting half of the respondents. Their role included teaching conservation techniques, advising on drought-tolerant crop varieties, and monitoring implementation. Peer learning was equally important, with 40% of respondents citing fellow farmers as sources of knowledge. Social learning provides opportunities for farmers to observe successful strategies, discuss challenges, and exchange local innovations, which can enhance adoption efficiency (Meijer *et al.*, 2015). NGO programs and training workshops supplemented these services, providing seeds, fertilizers, and practical demonstrations that build technical competence.

Despite the availability of support services, respondents reported gaps such as infrequent extension visits, delayed input delivery, and insufficient follow-up after training sessions. Radio and TV programs were considered supplementary but less effective due to accessibility limitations in remote areas. Chisanga *et al.* (2020) emphasize that gaps in support services can constrain farmers' ability to implement adaptive practices fully,

reducing potential yields and resilience gains. These findings underscore the importance of strengthening institutional support, providing timely inputs, and integrating both formal and informal knowledge systems to maximize the impact of adaptive strategies.

4.6 Discussion of research findings

The results of this study provide valuable insights into the demographic characteristics of farmers, their adoption of adaptive farming practices, the perceived effectiveness of these strategies, and the role of support services in enhancing resilience to drought. When compared with findings from existing literature, several patterns emerge that confirm, complement, or contrast with previous research.

The demographic analysis revealed that maize farming in the study area is predominantly male-dominated, with 65% of respondents being men. This finding is consistent with FAO (2018) ^[10], which argues that cultural norms in sub-Saharan Africa often position men as decision-makers in agriculture due to their control over land and financial resources. However, women remain heavily involved in labor-intensive activities such as planting, weeding, and harvesting. Similar observations have been made by Doss (2013), who noted that despite women's central contribution to food production, their roles are often undervalued, limiting their access to resources and training. This suggests that without gender-sensitive interventions, adaptive strategies may continue to favor men, thereby excluding women from climate-resilient agriculture despite their crucial role in production.

The age distribution of respondents indicates that the farming population is relatively young, with 50% aged between 25 and 35 years. This aligns with findings by Chisanga *et al.* (2020), who reported that younger farmers in Zambia are more willing to experiment with new practices and adopt innovations such as conservation farming and drought-tolerant crops. The predominance of younger farmers is a positive factor for the scaling of adaptive strategies, given their receptiveness to training and use of modern technologies. However, the smaller proportion of older farmers raises concerns about the loss of traditional ecological knowledge. This echoes the argument by Nyanga (2012) that intergenerational learning is critical for sustainable adaptation, as it combines experiential wisdom with innovation.

Education levels were found to be generally high, with 40% of respondents having completed secondary education and 20% possessing tertiary qualifications. This is consistent with Muzerengi and Phiri (2019), who emphasize that education significantly enhances farmers' ability to adopt and apply adaptive practices, particularly in interpreting weather forecasts and understanding technical information. Nevertheless, the 5% of farmers with no formal education reflect the literacy gap that persists in rural areas, reinforcing the need for inclusive extension methods such as demonstrations and visual learning tools (Mutekwa, 2018). This ensures that all farmers, regardless of education level, benefit equally from adaptation initiatives.

Similarly, farming experience emerged as a key determinant of adaptation, with 75% of respondents having more than five years of experience. This finding is consistent with Deressa *et al.* (2011), who found that farming experience correlates positively with the adoption of drought-resilient

strategies. Experienced farmers are better able to judge risks and apply coping mechanisms based on past events. However, newer farmers may lack this knowledge and thus depend more on extension support, highlighting the importance of mentorship and knowledge transfer. Farm size also proved influential, with the majority cultivating less than two hectares. This reflects the typical smallholder farming structure in Zambia (Sitko & Jayne, 2014). Small land sizes limit investment in large-scale adaptive infrastructure, confirming FAO's (2018) ^[10] assertion that smallholders require context-specific, low-cost strategies such as mulching, crop rotation, and drought-tolerant maize varieties.

The study revealed that farmers employed multiple adaptive practices, with conservation farming (65%) and drought-resistant maize varieties (60%) being the most common. This mirrors findings by Ngoma *et al.* (2020), who reported widespread adoption of conservation farming in Zambia due to its effectiveness in improving soil fertility and water retention. Similarly, the adoption of drought-tolerant maize varieties reflects trends documented by CIMMYT (2015), which highlighted their increasing role in enhancing food security in drought-prone regions. Less commonly adopted practices such as agroforestry and water harvesting correspond with literature that notes labor and capital constraints as major barriers to uptake (Meijer *et al.*, 2015). Thus, the variation in adoption rates observed in this study supports the argument that while farmers are willing to adapt, their choices are constrained by resource availability.

Extension officers emerged as the primary source of information (50%), followed by peer learning (40%) and NGOs (35%). This confirms findings by Nyanga (2012) and Meijer *et al.* (2015), who noted that farmers rely heavily on both formal extension systems and informal social networks for knowledge acquisition. Peer-to-peer learning plays an especially critical role in enhancing adoption, as farmers often trust and replicate practices they observe within their own communities. However, gaps such as infrequent extension visits and limited NGO coverage remain consistent with challenges highlighted by Chisanga *et al.* (2020). This underlines the need for strengthening farmer support services to ensure timely, accessible, and continuous training.

Farmers in this study reported significant yield improvements, from an average of 20-30 bags per hectare without adaptive practices to 80-120 bags with adaptive farming practices. This is in line with Deressa *et al.* (2011), who found that adaptive practices increase productivity and resilience even under adverse climatic conditions. The fact that 85% of respondents rated these practices as very effective or moderately effective suggests a high level of confidence in adaptation strategies. Similar findings were reported by Ngoma *et al.* (2020), who noted that integrated practices, such as combining conservation farming with drought-tolerant maize, create synergistic benefits. However, the 15% of respondents who found practices ineffective point to the challenges of poor input access and labor shortages, which are consistent with the limitations identified in the broader literature (FAO, 2018) ^[10].

Overall, the findings corroborate much of the existing literature on adaptation in smallholder agriculture while also highlighting localized nuances. The predominance of male farmers reinforces gendered barriers that persist in African agriculture, while the youthful nature of the farming

population presents opportunities for rapid scaling of adaptive practices. Education and experience enhance adoption, but constraints of land size and resource access remain major obstacles. Adaptive practices are clearly effective, but their full potential can only be realized through strengthened support services, gender-sensitive policies, and integrated approaches that blend modern techniques with.

5. Summary, Conclusions, and Recommendations

5.1 Overview

This chapter presents a synthesis of the research findings, draws overarching conclusions, and provides recommendations based on the study of the effectiveness of adaptive farming practices in mitigating the effects of prolonged droughts among smallholder maize farmers during drought periods. While Chapter Four detailed the quantitative and qualitative findings, this chapter consolidates these results, highlighting their implications for drought resilience, sustainable agricultural practices, and food security in the study area.

The chapter is structured into three main sections. First, a summary of the key findings is presented, linking the demographic characteristics of respondents to the adoption and effectiveness of adaptive strategies. Secondly, the chapter provides conclusions that reflect the broader significance of these findings, including socio-economic and policy-related implications. Thirdly, evidence-based recommendations are offered to enhance the adoption, effectiveness, and sustainability of adaptive farming practices. By doing so, the chapter aims to provide actionable insights for farmers, agricultural extension services, policymakers, and development partners.

5.2 Summary of Key Findings

The study revealed several important insights into the adaptive strategies employed by smallholder maize farmers during drought periods. The demographic profile of respondents showed that maize farming is predominantly male, with 65% of farmers being men, and that the majority of farmers are young, aged between 25 and 35 years, representing 50% of the sample. Education levels were generally sufficient to facilitate understanding and adoption of adaptive practices, with 40% of respondents having completed secondary education and 20% tertiary education. Farming experience was largely concentrated in the range of 5–10 years, which provides a balance of practical knowledge and openness to new innovations. These demographic characteristics suggest that farmers are well-positioned to adopt adaptive techniques, though gender imbalances and small farm sizes may influence access and participation.

In terms of farm size, most respondents cultivated plots between 1 and 2 hectares, highlighting the smallholder nature of maize production. This limited land size constrained the feasibility of resource-intensive strategies, such as large-scale irrigation or mechanized conservation farming, but encouraged the use of cost-effective, labor-efficient methods such as mulching, early planting, and the use of drought-resistant maize varieties. The study also revealed that farmers are actively employing multiple adaptive strategies, with conservation farming, drought-resistant maize, and early planting being the most common. Less widely adopted practices, including crop rotation,

water harvesting, and agroforestry, were constrained by labor demands, limited inputs, and technical knowledge. The integration of multiple strategies demonstrates farmers' recognition of the benefits of combining methods to mitigate drought stress, consistent with literature highlighting the synergistic effects of integrated adaptive practices.

Regarding effectiveness, the study showed that adaptive practices significantly improved maize yields. Farmers reported yield increases from an average of 20-30 bags per hectare without adaptive practices to 80-120 bags per hectare with the adoption of these strategies. The majority of respondents perceived these practices as very effective or moderately effective, and a similar proportion indicated their intention to continue using them in future drought seasons. These findings suggest that adaptive practices enhance drought resilience and food security, while variability in effectiveness was observed due to differences in farm size, access to inputs, and the correct application of techniques.

The study further highlighted the critical role of support services in enabling the adoption and effective use of adaptive strategies. Extension officers, peer networks, NGOs, and training workshops were identified as key sources of knowledge, technical guidance, and inputs. Nevertheless, gaps such as irregular extension visits, delays in input delivery, and insufficient follow-up training were noted, indicating areas where service provision could be strengthened. Open-ended responses illustrated that farmers adopt adaptive practices to improve crop survival, maintain or increase yields, and preserve soil moisture, reflecting both practical experience and awareness of long-term benefits.

5.3 Conclusions

From the findings, it is evident that the demographic and socio-economic characteristics of farmers influence the adoption of adaptive practices. The relatively young, educated, and moderately experienced farming population is more likely to experiment with innovative strategies while retaining traditional knowledge that is critical for responding to environmental cues. Despite a male-dominated population and small farm sizes, farmers demonstrate resilience through the adoption of multiple adaptive techniques that are effective even under resource constraints.

Adaptive practices such as conservation farming, drought-resistant maize varieties, early planting, and mulching have proven effective in improving maize yields and maintaining productivity during drought periods. Farmers' willingness to continue using these practices indicates recognition of their value in promoting both immediate and long-term agricultural sustainability. However, the effectiveness of these practices is influenced by factors such as resource availability, technical knowledge, and farm conditions.

Support services play a central role in enabling farmers to adopt and implement adaptive strategies effectively. Extension officers, NGOs, training workshops, and peer learning networks provide knowledge, guidance, and inputs that enhance farmers' capacity to manage drought risks. Gaps in service provision, including infrequent visits and limited access to inputs, present challenges that may reduce the consistency and effectiveness of adaptive practices.

Overall, the findings underscore the importance of integrating demographic, socio-economic, and institutional factors when designing and implementing adaptive

strategies. An integrated approach that combines multiple adaptive techniques, strengthens support services, and addresses resource and knowledge gaps can enhance drought resilience, improve yield stability, and support sustainable maize production among smallholder farmers.

5.4 Recommendations

Based on the findings and conclusions, the study recommends the following:

Strengthen Extension Services: Increase the frequency and coverage of extension officer visits, with a focus on practical demonstrations of less commonly adopted practices such as water harvesting and agroforestry.

Promote Integrated Adaptive Practices: Encourage farmers to adopt multiple strategies simultaneously, such as conservation farming, drought-resistant maize, early planting, and mulching, to maximize drought resilience. Provide practical, evidence-based training to ensure proper implementation.

Enhance Access to Inputs: Facilitate timely provision of critical inputs, including drought-resistant seeds, fertilizers, and mulching materials. Consider subsidy programs or micro credit schemes to support smallholder farmers in acquiring necessary resources.

Support Knowledge Sharing and Peer Learning: Establish community-based learning platforms or farmer field schools where farmers can exchange experiences and lessons learned. Promote mentorship programs connecting experienced and younger farmers to preserve traditional knowledge while fostering innovation.

Leverage Media and Technology: Use radio, television, and mobile-based platforms to disseminate timely information on drought forecasts, recommended adaptive practices, and market opportunities, ensuring accessibility for all farmers.

Address Gender Inequalities: Design gender-sensitive programs that ensure women have equitable access to resources, training, and decision-making opportunities, recognizing their significant contribution to maize production.

Strengthen Policy and Institutional Support: Enhance collaboration between government agencies, NGOs, and farmer groups to provide coherent and sustainable support. Integrate adaptive practices into local agricultural development and climate resilience policies to ensure long-term impact.

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