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ADAPTATION OF CLIMATE VARIABILITY RESILIENT CROPS AMONG RURAL HOUSEHOLDS OF MALIMA FARMING BLOCK IN SINAZONGWE DISTRICT, SOUTHERN ZAMBIA.

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This paper examined the adaptation of climate variability resilient crops among rural households in the Malima Farming Block (MFB) of Sinazongwe District, Zambia. It is an excerpt from a Master of Science in Geography dissertation. The main objective was to identify strategies suitable for enhancing the adaptation of climate variability resilient crops among rural MFB households. A qualitative approach, based on a descriptive research design, was employed. Expert and critical case sampling purposive sampling techniques were used to select 60 participants, comprising 48 heads of small scale farming households and 12 key informants. The Sustainable Livelihoods Model (SLM) was used. The study found that climate resilient varieties, such as sorghum and millet, could withstand prolonged dry spells, as they were able to survive on dew. It also identified several strategies such as conservation practices within Climate Smart Agriculture, developing climate resilient hybrid varieties, promotion and distribution of traditional climate resilient crops such as millet and sorghum. There would be a need also to integrate and ensure market access for such crops.
The paper recommends that small scale farmers should receive training in cultivating a range of drought resilient crops; conservation agriculture practices such as crop rotation, cover cropping, and zero tillage should be effectively implemented among small scale farmers. Finally, the paper recommends that stakeholders adopt a holistic approach in addressing the factors influencing the adaptation of climate variability - resilient crops.

Keywords: Climate Variability, Climate Variability Resilient Crops, Climate Variability Suitable Strategies, Community Engagement, Adaptation

Background

Despite the government's policies and interventions in promoting the adaptation of climate variability resilient crops, there is limited and unclear evidence regarding the extent to which local small scale farmers in MFB have participated in and adopted these measures and strategies.

This study was conducted to ascertain the extent of adaptation of drought resilient crops among rural households in MFB, Sinazongwe District, Southern Zambia. This is an excerpt, part of the Master of Science in Geography (MSc) programme pursued at Kwame Nkrumah University (KNU). Climate change continues to negatively affect many key economic sectors across the globe. According to the National Oceanic and Atmospheric Administration (NOAA, 2023), the period between 2000 and 2019 was the warmest in the past 1,300 years. The year 2022 ranked as the sixth warmest year on record, with a temperature increase of 0.86°C since 1880. During the first half of 2021, Oregon recorded an extreme temperature of 48.8°C, while Death Valley in California reached 54.4°C (The Guardian, 2023). Africa is warming at a faster rate than the global average. Surface temperatures across the continent have risen by about 1°C since the late 19th century, with some areas such as the Sahel region experiencing increase of up to 3°C at the end of the dry season (IPCC, 2014).

Zambia has also experienced rising temperatures, particularly in the Southern and Western regions. Since 1960, the country's mean annual temperature has increased by approximately 1.3°C, at an average rate of 0.29°C per decade (World Bank, 2020). Climate projections suggest that Zambia's mean annual temperature is expected to rise by between 1.2°C and 3.4°C by 2060. Additionally, research indicates that by 2050, the mean temperature could increase by 1.82°C, while rainfall is projected to decline by 0.87% (Kalantry, 2010).

The rise in temperature and variability in precipitation patterns have posed significant challenges to crop production. Projected increases in temperature, changes in precipitation, and the occurrence of extreme weather events are expected to negatively impact global agricultural production, as the sector depends heavily and directly on land, water, and other natural resources that are affected by climate change (Walsh et al., 2020; Gowda et al., 2018).

A study conducted by the USDA's Economic Research Service from 2011 to 2019 revealed a reduction in the growth of global agricultural output, from 1.96% in the 2000s to 1.31% in the 2010s. Furthermore, agricultural output slowed, growing at an average annual rate of 2.08% from 2011 to 2019, compared with 2.68% during 2001 to 2010. This slowdown has been observed primarily in developing countries, with Asian countries leading (Fuglie et al., 2021). The impacts of climate variability and change has not spared the African continent. Julie et al., (2023) projected that food production and yields in Africa may decline, and the continent would only be able to meet 13% of its food needs by 2050.

Zambia, like other developing countries, has not been spared from the impacts of climate change and its variability, particularly in the agricultural sector. Agriculture provides 80% of the country's domestic food supply and contributes approximately 9% to Gross Domestic Product (Filho, 2020). However, the sector is highly vulnerable to climate change due to its heavy reliance on rainfall. Since 1960, the country has experienced a decrease in rainfall at an average rate of 1.9 mm/month (2.3%) per decade, with the rainy season becoming shorter and more unpredictable, and rainfall events occurring less frequently but with greater intensity (AfDB, 2019). Climate change continues to pose serious challenges to Zambia's efforts to combat poverty, reduce food insecurity, and manage natural resources sustainably (USAID, 2012). This situation exacerbates the risk of hunger and poverty, particularly in the MFB, especially if climate variability resilient crops are not widely adopted.

The droughts of 2004 to 2005 and 2015 to 2016, caused by El Niño, reduced households' maize yields by approximately 20% and income by 37% (Filho, 2020; USAID, 2012). Furthermore, the El Niño induced dry weather patterns during the 2023/24 farming season resulted in prolonged dry spells, causing droughts that affected 84 out of the country's 154 districts (Chisalu, 2024). This led to decreases in the production of rice, cassava, soya beans, sweet potatoes, millet, and sorghum. Maize, the country's staple food, was the most severely affected, with approximately 1 million hectares of an estimated 2.2 million hectares planted impacted, thereby affecting over one million farming households (Chisalu, 2024). Production further declined from 3.3 metric tonnes to 1.5 metric tonnes, below the projected 3.2 metric tonnes, resulting in a deficit of 1.7 metric tonnes (Chulu, 2024), a situation that is particularly concerning for the MFB.

Over the years, the Zambian government has formulated national policies to mitigate the impacts of climate change, including the National Adaptation Plan of Action (NAPA, 2007), the National Climate Change Response Strategy (2010), and the National Policy on Climate Change (2016) (Irish Aid, 2017). These policies aim to address the impacts of climate change and its variability. Furthermore, the government incorporated environmental sustainability and climate change mitigation measures into the Eighth National Development Plan (8NDP) 2022 to 2026 (Santosh, 2023). The 8NDP is aligned with Vision 2030, which seeks to achieve Zambia's long-term aspiration of becoming a prosperous middle income nation (MFNP, 2022). The framework also integrates Sustainable Development Goals (SDGs) 2 and 13, which are designed to end hunger, achieve food security, improve nutrition, promote sustainable agriculture, and take urgent action on climate change and its impacts respectively.

In addition, the government, together with other stakeholders, has been promoting the adaptation of climate variability resilient crops as a viable strategy. Climate resilient varieties are those with enhanced tolerance to biotic and abiotic stresses, enabling them to maintain or increase yields under challenging conditions (Zohry & Ouda, 2022; Dhankher & Foyer, 2018). The strategy aims to build agricultural resilience systems that can significantly enhance farmers' capacity to cope with climate change (Acevedo et al., 2020).

Research Model

The study was anchored on the Sustainable Livelihoods Model, which aims to understand and improve the lives of people experiencing poverty and uncertainty by focusing on factors that constrain or enhance their opportunities. It is a participatory approach based on the belief that people living in poverty possess abilities and assets that can be leveraged to help them manage and improve their lives (Oxfam, 2013). The model assumes that communities should be able to cope with and recover from stresses and shocks while maintaining or enhancing their capabilities, assets, and activities, without undermining the natural resource base (Serrat, 2008). This assumption was applied to the study, as small-scale farmers utilized locally available resources to navigate the impacts of climate change and its associated effects.

Description of the Study Area

Sinazongwe District is located in the Southern Province of Zambia, within the Zambezi Valley of the Great East Rift Valley. The district shares its borders with Choma District to the West, Gwembe District to the North, and Kalomo District to the Southwest. Sinazongwe District comprises two chiefdoms, namely Chief Sinazongwe and Chief

Mweemba, and five farming blocks: Sinazeze, Sinazongwe, Mweemba, Maamba, and Malima. Malima Farming Block (MFB) is part of the Zambezi Valley, an extension of the Great East Rift Valley, which spans longitudes 26°43′E to 27°45′E and latitudes 16°50′S to 18°00′S (Zambia Meteorological Department, 2010).

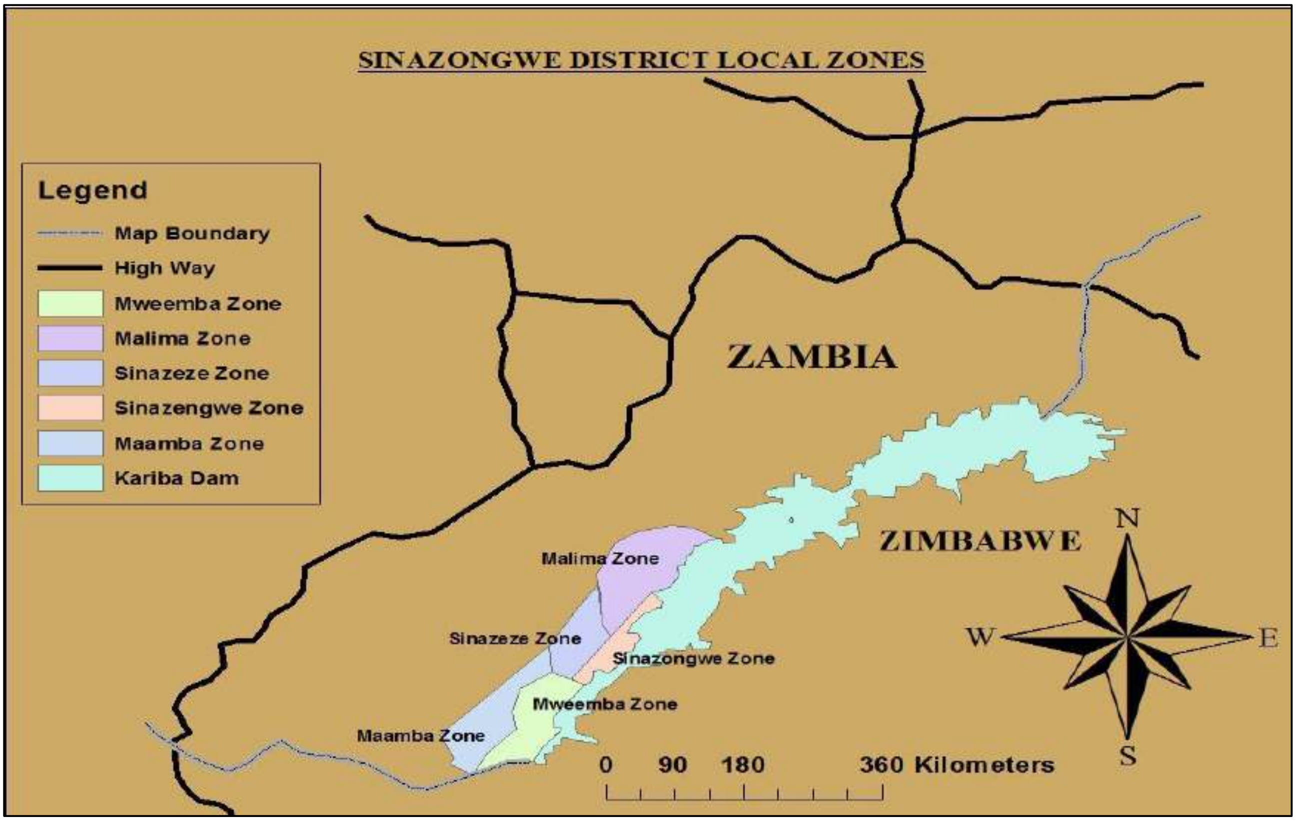

Figure 1: Location of Malima Farming Block in Sinazongwe District
Source: Source: (CSO 2010 and ZMD, 2008) in Syambwata (2019).

The study area was selected due to its geographical location within a district that is highly vulnerable to climate variability shocks, such as droughts and floods. The area experiences variable rainfall patterns and is among the driest regions in the country, significantly affecting agricultural productivity. Sinazongwe District typically experiences low maize production due to drought conditions (Sindaaza, 2013). Furthermore, within MFB, community projects such as goat empowerment and water harvesting have been promoted to mitigate the impacts of climate variability. The study area was further chosen because of its historical agricultural production capabilities, having once been among the country's food basket regions over the past 20 years, and its current low agricultural productivity (World Bank, 2007).

Data Sources

The study used both primary and secondary data sources. Primary data were obtained through a semi-structured interview guide administered to key informant participants and through Focus Group Discussions (FGDs) conducted with heads of small-scale farming households. Secondary data were collected from written sources, including books, peer-reviewed journal articles, dissertations, and government policy documents and reports.

Sampling strategy and sample size

The study employed expert and critical purposive sampling strategies. Key informants were selected using critical purposive sampling, as they possessed specialized knowledge that provided a deeper understanding of climate variability adaptation. Small scale farming households were also sampled, focusing on those who had lived in the area for an extended period or were involved in cultivating climate variability resilient crops.

A total of sixty (60) participants were included in the study, comprising 12 key informant participants and 48 heads of small-scale farming households. The study was primarily qualitative, and based on the principle of saturation. As noted by Guest et al., (2006), a minimum of 5 to 30 participants and a practical maximum of 30 to 60 participants is sufficient to achieve saturation and obtain the desired results.

In addition, a total of four Focus Group Discussions (FGDs) were organized to provide an in-depth understanding of the adaptation of climate variability resilient crops. Each FGD comprised twelve participants, including both men and women who were considered to have valuable information and insights on the adaptation of climate-resilient varieties, factors influencing adaptation, and strategies important for promoting effective adaptation.

Data collection

The study employed a semi-structured interview guide, which allowed the researchers to probe key informants to obtain deeper insights and in-depth information on adaptation. The FGDs with heads of small-scale farming households were conducted using the same questions applied to the key informants. The researchers coordinated the FGD sessions, and responses were recorded. During these discussions, participants were encouraged to share their experiences. The sessions facilitated in-depth interactions, as the researchers had the opportunity to probe group members and compare their perceptions regarding the adaptation of climate variability resilient crops. This information contributed to the triangulation process with data collected from key informants.

Data Processing and Analysis

The collected data were recorded, cleaned, and thematically coded based on emerging themes. This was followed by analysing data using inductive approach. Following data collection, coding was performed, which is a crucial step in qualitative analysis as it involves the identification of significant themes and patterns (Strauss & Corbin, 1998). Coding allowed the information to be organised into basic descriptive data, which were summarised in frequency tables (Saldana, 2015). Responses from all FGDs were verified and triangulated. Major themes were further divided into sub-themes. FGD data are presented as direct quotations, reflecting the experiences and views of the participants. Triangulation using multiple data sources was employed to ensure the reliability and validity of the findings. Since this was qualitative in nature, to test reliability and validity, three major features of trustworthiness, namely credibility, dependability and Conformability were tested. This was through member checking, and conformability where in both, the researchers had to confirm with participants on whether what they captured was what they said. This was accompanied by audit trail. Triangulation was also affirmed in that various instruments used to collect data had some similar or common questions. Using such helped to validate the data collected. At times same questions were asked at different points to test whether researchers would get same or similar answers.

Findings and Discussions

Perceptions of Climate Variability

The perceptions of rural households regarding climate variability are critical in shaping the adaptive responses of small scale farmers. These perceptions are presented in Table 1.

Table 1. Key Informants' Perceptions of Climate Variability

Perceptions of Climate Variability	Number of Participants	% of Participants
Changes in weather and climate	04	36.4
Changes in seasons	03	27.3
Changes in rainfall and temperature	03	27.3
Non-Response	01	9.0
TOTAL	**11**	**100**

Source: Field data (2024)

The findings indicate that the majority, 4 (36.4%) of key informant participants, perceived climate variability as changes in weather and climate, while 3 (27.3%) perceived it as changes in seasons and in rainfall and temperature patterns, respectively. One key informant, indicated that *"it was currently difficult to know if it was autumn or winter, as things drastically changed"* (K-8). The responses from key informant participants were consistent and corroborated by the discussants in the FGDs. For instance, some FGD participants reported that *"climate variability refers to changes in weather patterns over time; it also means extreme heat and cold"* (FG-3).

Additionally, some discussants argued that *"climate variability means drought, low rainfall, or the abrupt cessation of rainfall without any warning"* (FG-2). However, the findings from FGD-4 differed from those of the other groups, as participants perceived climate variability to mean *"a lot of rain and flooding over a short period"*. Small scale farmers on the lower plains of MFB, who frequently experience flooding, perceived climate variability as flooding, whereas those on the upper plains, experiencing erratic and low rainfall, perceived it as drought.

The implication is that direct personal experiences of extreme weather events, such as floods and droughts, increase individual awareness and concern about climate variability. Furthermore, geographic location and cumulative years of experience through repeated exposure to climate related events reinforce individual understanding and perceptions of climate variability. This exposure ultimately influences the types of climate variability resilient crops that small scale farmers choose to cultivate. Concerning the number of years some participants spent on MFB, findings indicated that the majority 6 (54.5%) of key informants, had worked for 15 years or more and had spent 10 to 14 years in MFB serving their respective institutions. This suggests that the participants possessed extensive personal and comprehensive understanding of changes in climate patterns over time. They also had experience observing how people in MFB, particularly small scale farmers, were adapting to climate variability through agriculture. The duration of their stay in MFB facilitated the identification of long term trends, patterns, challenges, and success rates associated with the adaptation of climate variability resilient crops.

In addition, perceptions of climate variability were shaped by long term personal experiences of rainfall patterns as indicated in Fig. 2.

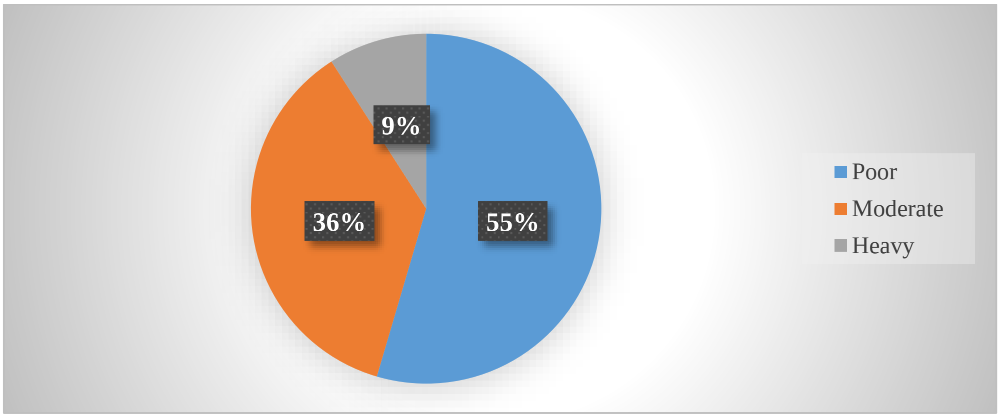

Fig. 2. Key Informants' Perceptions on Rainfall Pattern and Intensity
Source: Field data (2024)

Findings from Fig. 2 show that 7 (55%) of the key informant participants perceived rainfall pattern and intensity as poor, while 4 (36 %) perceived it as moderate. Furthermore, of the 11 key informants, 8 (72.7%) interpreted rainfall variability as seasonal changes in rainfall while 3 (27.3%) viewed it as climate variability.

Overall, the findings indicate a decreasing trend in rainfall pattern and intensity. One key informant described climate variability as changes in weather patterns, stating: *"Climate variability is seasonal rainfall variability…the last time Malima area received sufficient rainfall was around 2016 to 2017*; *recently, rainfall has decreased and is usually poorly distributed"* (K-1).

The findings from key informant participants were consistent with the responses from participants in some Focus Group Discussions (FGDs), who perceived rainfall variability as *"a challenge here…it starts early and ends early…There is no positive expectation from the rains these days, as it is usually not enough"* (FG-3). The discussants further reported that *"the rainy season is now difficult to predict. Sometimes, the rains start on time in October or November*, *but end abruptly"* (FG-1).

The study revealed that MFB had been experiencing decreased rainfall amounts since 2016. This decline had negatively affected agricultural production, prompting small scale farmers to be encouraged to adopt climate variability resilient crops as a mitigation measure. The findings on farmers' perceptions of climate variability were consistent with the works of Balasha et al., (2023) and Wabwire et al., (2020) who reported that small scale farmers commonly perceived climate variability as changes in rainfall patterns particularly the onset and cessation of rains as well as increased temperatures and frequent, prolonged droughts. *ax*

Perceptions of Rural Households over the Growing of Climate Variability Resilient Crops

The findings of the study on perceptions regarding the growing of drought resilient crops revealed common views among both key informant participants and heads of small scale farming households. One key informant participant explained that *"adaptation of climate variability crops was the growing of crops that could survive in areas with less rainfall and could not be damaged by drought. It was a solution to mitigate the impact of drought resulting from climate change"* (K-1). This view was supported by another key participant who stated that *"climate variability resilient crops were perceived as high yielding crops suitable for drought-prone climatic conditions"* (K-5). Similar sentiments were echoed across all the focus group discussions (FGDs). For instance, discussants in FG 2 and FG 3 stated that *"climate variability crops were crops that could survive in areas with little rainfall or on dew"*.

These crops were perceived as effective strategic measures that could help small scale farmers increase agricultural productivity, improve household food security, and establish a strong foundation for climate variability resilient farming systems. The findings align with those of earlier studies, which concluded that the adaptation of drought resilient crops is one of the viable solutions to mitigate the impacts of climate change (Alemu, 2018; Mabhaudi et al., 2016).

As a result, small scale farmers were growing different types of climate variability resilient crops, as indicated in Fig. 3, to mitigate the impacts of climate variability. The majority, 5 (45.5%) key informant participants, indicated that finger millet was one of the major climate variability resilient crops grown in MFB, followed by sorghum at 3 (27.3%) and cowpea at 2 (18.2%), while cotton was the least cultivated. These crops were adopted because of their ability to withstand drought. As stated by one key informant (K-1), *"Climate variability resilient crops are typically more tolerant to water stress and have better survival rates during dry periods. The crops have deeper root systems, improved water use efficiency, and better adaptability to fluctuating weather conditions"*. This was supported by another participant (K-5), who noted that *"climate variability resilient crops perform well under drought conditions. They are resistant to diseases and pests and have high yielding capacity"*. Another key participant added, *"Malima is a dry, hot spot area… local maize such as Kafwamba is helpful due to its shorter maturity period"* (K-9).

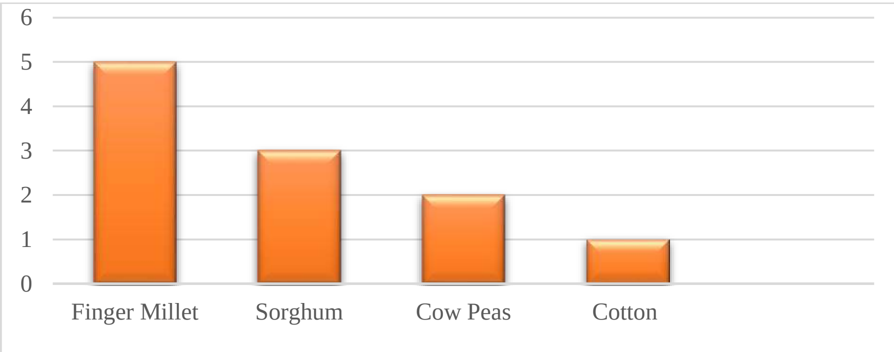

Figure 3. Types of Climate Variability Resilient Crops
Source: Field data (2024)

The findings of this study were consistent with other research conducted on the types and preferred varieties of climate variability resilient crops. For example, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, 2017) found that sorghum and millet are highly tolerant to drought, yielding up to 70% more than maize under drought conditions. Similarly, a study by Vadez et al., (2012) indicated that both sorghum and millet perform efficiently in semi-arid regions. Research conducted by the University of Zambia and the Institute of Tropical Agriculture (ITA) further revealed that cowpea is a drought-resistant legume capable of fixing nitrogen and improving soil fertility (UNZA, 2019).

Factors Affecting Rural Households of MFB in Adapting Climate Variability Resilient Crops

Adapting to the challenges of climate variability through the cultivation of climate resilient varieties is crucial for mitigating its effects and enhancing food production. However, the adoption of these crops was influenced by several factors, as shown in Table 2.

Table 2: Factors Affecting Adaptation of Climate Variability Resilient Crops

Factors Affecting Adaptation	No. of Participants	% of Participants
Environmental related factors	6	54.5
Social and Economic factors	2	18.2
Technological factors	1	9.1
Governance related factors	2	18.2
Total	**11**	**100**

Source: Field data (2024)

Findings show that the majority, 6(54.5%) of participants, identified environmental factors such as rainfall variability, temperature fluctuations, flooding, pests, and diseases as the main challenges affecting the adaptation of climate variability resilient crops. One participant stated that *"there was a change in the amount of rainfall… mainly it was characterised by a heavy shower lasting for just a few hours, usually windy with little impact on soil moisture"* (K-5).

Another key informant added that*"pests were affecting plant growth and production in the area. Armyworms fed on crops, especially maize, leading to poor plant growth. When maize is attacked at the tasselling stage, production is usually affected, resulting in low yields"* (K-3).

The findings clearly indicated that biophysical factors such as poor rainfall, high temperatures, and the frequent occurrence of crop diseases negatively affected the adaptation of climate variability resilient crops in MFB. As a result, the rate of adaptation of these crops remained slow, contributing to high poverty levels in the area. Technological factors were identified as the least influential, including limited use of telephones and radios. Most small scale farmers in MFB lacked access to modern technological tools and, consequently, had limited information on the adaptation of climate variability resilient crops.

In addition, social and economic factors such as lack of marketing opportunities for traditional crops, as shown in

Fig. 4 were significantly affecting the adaptation of climate variability resilient crops. Figure 4 indicates that 7 (63.3%) of the key informant participants reported that market opportunities for traditional climate variability resilient crops, such as millet and sorghum, were poor, while slightly over one-third of the participants described them as good or moderate.

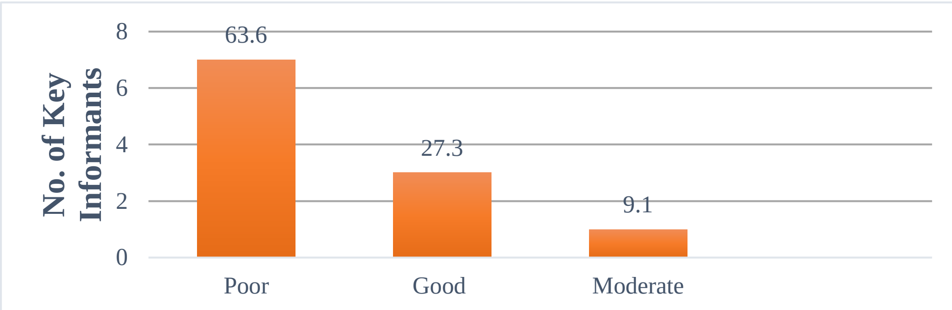

Fig. 3. Marketing Opportunities for Traditional Climate Variability Crops
Source: Field data (2024)

The findings from the key informant participants on factors affecting the adaptation of climate variability resilient crops were consistent with those of the FGD discussants, who stated that *"crops like millet and sorghum, even if you grow them in large quantities, there was no market here"* (FG-3).

The findings of this study are comparable to research conducted in sub-Saharan Africa, where drought is a recurring environmental challenge that exposes small scale farmers to the impacts of climate change and variability (Ouma et al., 2017; CGIAR, 2019). Consequently, the study findings align with those of Lobell et al., (2011) and Cokola et al., (2021), which confirm that increasing temperatures reduce yields of staple crops such as wheat and maize, with a 1°C rise in temperature resulting in an approximate 10% reduction in crop yield, and overall yield losses reaching up to 40% under extreme conditions.

Poor market access for agricultural products discourages many small scale farmers from adopting climate variability resilient crops. The findings of this study are therefore consistent with those of Kassie et al., (2015), who indicated that lack of access to markets deters farmers from investing in new crop varieties due to fear of market failure. Furthermore, limited market information, inadequate credit facilities, and other associated risk factors make it difficult for small scale farmers to adopt climate variability resilient crops (Gbegbelegbe et al., 2017).

Implications of Climate Variability

Climate variability had both negative and positive implications in MFB. Details are given in Table 3 and Fig 4 respectively.

Table 3: Negative Implications of Climate Variability

Climate change variability implications	No. of Participants	% of Participants
Crop Failure and Reduced Production	7	63.6
Drought Leading to Water Shortage	3	27.3
Seasonal Flooding	1	9.1
Total	**11**	**100**

Source: Field data (2024)

Findings from Table 3 show that the majority, 7 (63.6%) of the participants identified crop failure and reduced production as the major impacts, while the minority 1(9.1%) indicated flooding as the least significant. Further, the findings indicated that during the 2022/23 farming season, maize production dropped from the projected 65,000 metric tonnes to 16,250 metric tonnes, representing only 25% of the expected output. During the 2023/24 season, maize production further declined from the projected 14,000 metric tonnes to 586 metric tonnes, representing a production rate of just 4.2% (Kilubi, 2024). Additionally, one participant from FG-3 stated, *"during the 2023/24 season, people in Malima Farming Block did not harvest anything, as you can see from the empty storage barns"*. The study's findings are consistent with those of Chapoto and Jayne (2011), who reported that a 1% increase in temperature and a 10% increase in rainfall led to 4.4% and 10% decreases in maize production, respectively. The findings also align with those of the USDA, which indicated that drought caused a 25% reduction in maize yields in Zambia (USDA, 2022). Similarly, the IPCC (2019) reported reductions in global wheat and maize production of 6 -12% and 7-15%, respectively. Therefore, climate variability contributes to reduced crop yields, shifts in growing seasons, and increased crop failures, particularly in vulnerable regions such as Sub-Saharan Africa, which are likely to experience heightened food insecurity (IPCC, 2019).

On the other hand, while some participants highlighted the negative impacts of climate variability, others perceived certain effects positively (Fig. 4). For instance, participants reported that *"flooding was very helpful for agricultural activities. It enabled people to grow crops on previously flooded riverbanks during the dry season, positively impacting their livelihoods by allowing them to engage in some form of winter agriculture"* (FG-4).

Floods often bring nutrient rich sediments that replenish soil fertility and moisture, provide water for irrigation, and thereby improve and support agricultural productivity (Wohl, 2011; Lafrenière, 2017). In the lower valley of MFB, the flooded areas along River Nang'ombe were used for agricultural activities, where small scale farmers grew winter maize under what they locally called 'Nchelela' (Fig. 4). The findings of this study are consistent with Hiwasaki et al., (2015), who indicated that flood-based livelihoods enhance climate resilience by providing a natural buffer against both drought and flooding.

Fig. 4 'Nchelela' Maize and Soya Beans Fields Grown on Once Flooded River
Source: Field data (2024)

Suitable Strategies for Adaptation of Climate Variability Resilient Crops among Rural Households of MFB

To ensure household food security, several adaptation strategies were suggested, including: (i) the integration of conservation practices into Climate SMART agriculture, (ii) hybriding, promotion, distribution, and provision of markets for traditional climate variability resilient crops such as millet and sorghum, and (iii) the provision of training to small scale farmers and coordination of seasonal migration. Some of the conservation agriculture strategies being practiced and integrated into Climate SMART agriculture as effective adaptation measures are shown in Fig. 5.

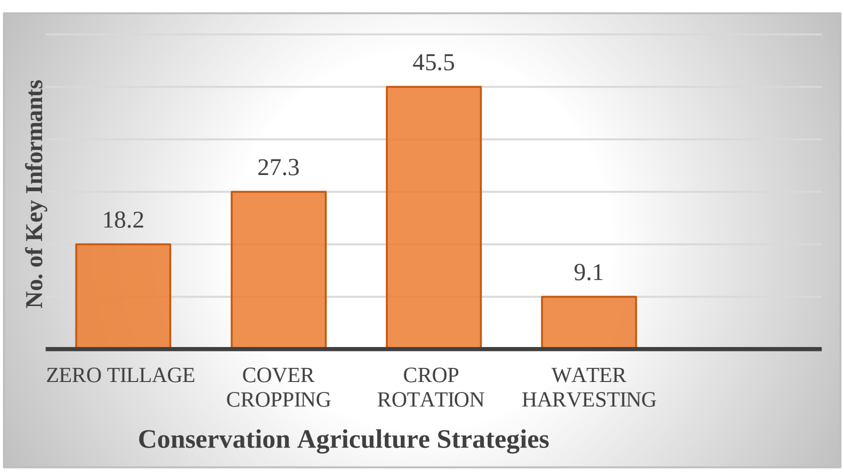

Fig. 5. Key Informants' Conservation Strategies integrated in Climate-SMART agriculture
Source: Field data (2024)

Findings in Fig. 5 the majority, 5 (45.5%) of the key informant participants, indicated that crop rotation was the most effective conservation agriculture strategy, and the minority, 1(9.1) indicated water harvesting as the least utilized. One key informant stated, *"crop rotation, cover cropping, agroforestry, and crop diversification are the best adaptation strategies, helping to promote the adoption of climate variability resilient crops"* (K-1).

One of the conservation agriculture strategies practiced in MFB was zero tillage, implemented through pot hoeing as shown in Fig. 6.

Fig. 6: Pot Hoeing Agriculture Conservation Method
Source: Field data (2024)

Hybriding, promotion, distribution, and market provision of traditional climate variability resilient crops to improve yield capacity were emphasized during discussions, with hybriding identified as a vital strategy to promote adaptation. One key informant stated, *"Hybriding of traditional crops such as millet, sorghum, soybeans, cowpeas, cotton, groundnuts, and sunflower, which are drought resilient in nature, could improve crop production. Companies involved in seed production are expected to convert most of the available drought resilient traditional crops into improved, high yielding varieties"* (K-1). This view was echoed by another participant, who argued, *"Seed companies are expected to improve their varieties, especially maize, a staple food for people of MFB, in response to the drastic changes in climatic conditions"* (K-8).

Provision of training to small scale farmers and the coordination of seasonal migration were other suitable measures proposed. One key informant stated, *"Farmers were taught various Climate SMART Agriculture strategies in farmers' training schools. Additionally, meetings were organized where farmers learned about conservation agriculture practices such as crop rotation, cover cropping, and crop diversification. During these meetings, testimonies were shared on the advantages of these adaptation strategies"* (K-5).

One FGD participant stated, *"The government, just as it does for maize, should provide market for crops such as watermelons, cucumbers, and millet to encourage more small scale farmers to grow traditional crop varieties and eventually flood the market with these crops"* (FG-3). Another participant advocated for the promotion of well-planned seasonal migration as an effective strategy, noting that *"organized and coordinated seasonal migration will provide opportunities for small scale farmers willing to engage in winter agriculture under the Nchelela system. Some climate variability resilient crops may also be grown intensively"* (FG-1).

The findings are consistent with numerous earlier studies, which concluded that Climate SMART agriculture practices reduce soil erosion and water loss, increase crop yields, improve agricultural productivity, and ultimately enhance resilience to climate variability (Derpsch et al., 2010; Nyagumbo et al., 2020; Unger et al., 2013; Lipper et al., 2014; Mwangi et al., 2019). The study also aligns with research by Chomba et al., (2020), which indicated that crop rotation and cover cropping significantly improve soil moisture retention, leading to a 25% increase in maize yields during drought years. Additionally, zero tillage practices, such as pot hoeing shown in Fig. 4, reduce soil erosion by 30% and improve soil organic matter, resulting in a 15% increase in soya bean yields. Furthermore, water harvesting increases water availability for irrigation, leading to a 40% increase in cowpea production during dry spells.

Furthermore, Wortmann et al., (2018) indicated that cover cropping reduces soil erosion by 50 -70% and increases organic matter, crop yield, and quality by 10 - 20%, while zero tillage reduces soil erosion by 27.3% and increases organic content by 18.2%. The study also recommended the cultivation of traditional climate resilient varieties. These crops are adaptive to local climate and soil conditions, making them more reliable in the face of climate change (AATF, 2013). Additionally, traditional climate variability resilient crops possess unique characteristics that enable them to thrive in challenging environmental conditions due to their high adaptive capacity (Bellon et al., 2013; Ismail et al., 2015). This highlights the importance of hybriding climate resilient crops, such as yams and millet, which can lead to increased yields, enhanced disease resistance, improved nutritional content, and a diversified crop portfolio (Bouis et al., 2001; FAO, 2019), thereby helping small scale farmers increase productivity. Moreover, the involvement of local agricultural extension services in promoting drought resilient varieties further enhances farmers' acceptance and adoption rates (Alemayehu et al., 2020).

This study employed the Sustainable Livelihood Model (SLM) to provide a clear understanding of how households and communities, particularly those experiencing poverty and uncertainty, manage their resources to achieve sustainable livelihoods in the face of climate variability. The findings indicated that the adaptation of climate resilient varieties was influenced by several model components, including natural, social, human, physical, and financial factors. Small scale farmers who utilized locally available assets such as land, financial resources, labour, farm machinery, human capital, and social networks had greater capacity to mitigate the impacts of climate variability and successfully adopt drought resilient crops. These findings are consistent with Julie et al., (2023), who argued that climate-related shocks significantly affect rural livelihoods, particularly in agriculture, and recommended the integration of climate-resilient agriculture into livelihood strategies. Thus, local resources played a critical role in mitigating the effects of climate variability and supporting the implementation of survival strategies.

The study eventually showed that small scale farmers were able to recover from climate stresses and shocks and enhance their capabilities, assets, and activities by utilizing the available natural resource base through the adaptation of various climate variability strategies. Using the Sustainable Livelihood Model, farmers leveraged locally available resources, particularly land, to navigate the impacts of climate variability by implementing appropriate adaptation strategies. This is particularly important because maize, a major staple crop, is highly susceptible to climate variability.

Conclusion and Recommendations

The study concludes that climate variability resilient crops, such as millet, sorghum, traditional maize varieties (Kafwamba), and Seedco 419, were perceived as high yielding and drought resilient crops capable of withstanding prolonged dry spells. However, the adaptation of these crops was influenced by several factors, including environmental, social, economic, and governance related challenges. Consequently, the study recommends several measures to enhance the adaptation of climate resilient varieties, and such include the following:

Policy Recommendations:

1. Given that the adaptation of climate variability resilient crops was influenced by multiple factors, the Ministry of Agriculture, District Agriculture Coordinating Officers, local agricultural extension officers, seed breeding companies, and NGOs should adopt a holistic approach to empower small-scale farmers with the necessary skills and information for adaptation and climate change mitigation.

2. There is a need of integration of conservation agriculture practices into Climate SMART agriculture; hybriding, promotion, distribution, and market provision for traditional crop varieties. This should be championed by the Ministry of Agriculture and its cooperating partners.

3. The identification of suitable strategies for the adaptation of climate resilient varieties, which can improve crop production and the overall adaptation process, should be implemented and integrated into agricultural practices among small scale farmers by the Ministry of Agriculture.

Academic Recommendations:

1. Since climate resilient varieties can withstand drought, it is recommended that the Ministry of Agriculture should train small scale farmers to grow a variety of drought – resilient crops with different maturity periods to spread climate related risks and enhance resilience.

2. There should be also the coordination of seasonal migration, especially after the training is done in order to increase on agriculture production. This should be coordinated by the Ministry of Agriculture.

Ethical Considerations

Participation by all participants in this was by voluntary and high confidentiality was exercised as identity of all participants remained anonymous. The rights of the participants were protected and respected.

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