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Assessing the Effects of Rainfall Variability on Household Food Security Among Smallholder Farmers: A Case Study of Nkeyema Ward, Nkeyema District

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Abstract

The impact of climatic variability on agricultural production is particularly severe in countries where rain-fed agriculture is the main source of livelihood. Smallholder farmers in Zambia are highly dependent on rainfall for crop production, making them especially vulnerable to climate variability. In Nkeyema District, unpredictable rainfall patterns have become more frequent, disrupting planting schedules, lowering crop yields, and threatening household food security. The main objective of this study is to assess the effects of rainfall variability on household food security among smallholder farmers in Nkeyema Ward, Nkeyema District. Specifically, it will (i) examine the relationship between seasonal rainfall variability and crop yield, (ii) assess the effects of rainfall variability on household food availability and dietary diversity, and (iii) evaluate coping and adaptation strategies employed by smallholder farmers to mitigate the impact of rainfall variability on food security. The study will adopt a descriptive case study design to collect both quantitative and qualitative data. A sample of

75 smallholder farmers will be selected using purposive and stratified random sampling to ensure representation across farming households. Data will be collected using structured questionnaires, supported by interviews and a review of secondary sources such as rainfall data records and agricultural reports. Quantitative data will be analyzed using descriptive statistics and correlation analysis to establish relationships between rainfall patterns, yields, and food security outcomes. Qualitative responses will be coded thematically to capture adaptation strategies and perceptions of climate variability. Results show that 54.7% of farmers described rainfall patterns as highly variable, while 48% reported significant reductions in crop yields linked to irregular rainfall. The effects extend to household food access, with 41.3% indicating that food availability had been severely reduced during erratic rainfall seasons. These findings highlight how fluctuations in rainfall not only disrupt agricultural productivity but also threaten nutritional well-being and economic stability in rural households.

Keywords: Rainfall Variability, Food Security, Smallholder Farmers, Crop Yield, Dietary Diversity, Adaptation Strategies, Nkeyema District

1. Introduction

This chapter will focus on the, background of the study, problem identification, purpose, rationale, objectives identification and stating the significance of the study. In addition, the research will outline the theoretical framework.

1.1 Background

Climate variability is an emerging serious global environmental problem affecting many sectors in the world (Getachew, 2017) and it continues to cause great environmental, social and economic threats to mankind with its multiple effects (Mikias, 2018). It undoubtedly influences the sustainable development of biodiversity, water, land and oceans as well as in relation to many sectorial activities especially the agricultural sector. According to IPCC (2018) [7] influences from climate variability impact, related extremes such as droughts and floods reveal substantial vulnerability and exposure of ecosystems and human systems. Agriculture which is the backbone of economy in many developing countries and is dominated by small-scale and subsistence

farming continues to be exposed and vulnerable to climate extremes (Field *et al.* 2022). In tropical regions, smallholder farmers face food insecurity due to numerous risks, including pest and disease outbreaks, severe weather events and market shocks, to cite a few, which all have a negative effect on smallholder agricultural production (Harvey *et al.* 2018).

To tackle climate extremes vulnerability many adaptive practices can be implemented at low cost when compared to the estimated risk (Adger, 2017). So that developing skills on designing and implementing short-term, medium-term and long-term sustainable adaptation strategies into today's risk and vulnerability assessment based on current environmental problems is necessary to strengthen response capacities and preparedness, to reduce risks (IFRC, 2019). Adaptation practices are critical and most efficient way to reduce the adverse impact of climate on the environment and on human livelihood (IPCC, 2007). Several studies have been confirmed that developing and implementing appropriate adaptation strategies increases food productivity. This can be achieved through the smallholder farmers themselves taking adaptive actions or by governments implementing policies aimed at promoting sustainable adaptation measures (Aung *et al.*, 2017).

The impact of climatic variability on agricultural production is particularly severe in countries where rain-fed agriculture is the main source of livelihood (Ochieng *et al.*, 2016) [11]. Africa in this regard is expected to experience adverse climate change impacts, particularly because of an increase in temperatures and decreased and more erratic rainfall (Asfaw *et al.*, 2018). As the amount of irrigated agricultural land is very low, agricultural production in Sub-Saharan Africa (SSA) depends on favorable weather conditions mainly during the rainy season (Dhakal *et al.*, 2016) [5]. Rurinda *et al.* (2014) said that smallholder farmers often use short-term coping strategies, like eating less or selling livestock, instead of investing in long-term adaptive strategies. These short-term fixes help right away, but they do not do much to help people deal with shocks in the future. The study also stressed how important outside support systems are for improving the ability of rural households to adapt. These include early warning systems, agricultural extension services, and access to credit. But many rural areas still do not have enough of these things, which makes them even more vulnerable.

Research from southern Zambia and Malawi (Mufute *et al.*, 2020; Ngwira & Chipungu, 2021) [8, 10] has shown that changes in rainfall often cause people to stop growing some traditional crops and switch to drought-resistant ones. This change might make things more resilient in the short term, but it could also limit food choices and lose local farming knowledge. Adaptation strategies often favor men over women who have less access to land, information, and decision-making power. This makes household-level responses to climate risks less effective. These structural inequalities make it even harder for some families to get enough food during seasons when it rains a lot.

1.2 Statement of the Problem

Over the past 20 years, it has become harder to predict how much rain will fall in sub-Saharan Africa. Because smallholder farmers depend on seasonal rain to grow their crops this change has made them more likely to be food insecure. Deressa (2011) say that even small changes in

when it rains can cause big drops in crop yields. Agriculture in Zambia makes up about 19% of the gross domestic product and more than 70% of the people depend on small-scale farming (Tembo, 2017) [15]. However, most of these farmers do not have the resources to deal with changes in the weather, which puts their crops and food supply at risk as recent records of the weather show that Zambia's rainfall has become more unpredictable over the past 15 years. Chisanga (2019) [3] found that in many parts of Western Province the rain has become less predictable with the rainy season starting later than usual and sudden dry spells during important growth stages. These problems have caused many crop failures especially for maize, which is the main food. The Zambia Vulnerability Assessment Committee (ZVAC, 2022) [16] says that almost 1.98 million people did not have enough food during the 2021/2022 season. Many of these families said they did not have enough food because the rain did not fall evenly. According to Mwiinga and Kalinda (2020) [9], it is hard to plan targeted interventions when there is not enough data at the local level. Farmers use coping strategies like cutting back on meals or selling things they own but these are often only temporary fixes that make them more vulnerable over time.

1.3 General Objective

To assess the effects of rainfall variability on household food security among smallholder farmers in Nkeyema Ward, Nkeyema District.

1.4 Specific Objectives

1. To examine the relationship between seasonal rainfall variability and crop yield among smallholder farmers in Nkeyema Ward.
2. To assess the effects of rainfall variability on household food availability and dietary diversity.
3. To evaluate smallholder farmers' coping and adaptation strategies to rainfall variability in relation to household food security.

1.5 Research Questions

1. How does seasonal rainfall variability affect crop yield among smallholder farmers in Nkeyema Ward?
2. What are the effects of rainfall variability on household food availability and dietary diversity?
3. What coping and adaptation strategies do smallholder farmers use to manage rainfall variability and maintain food security use?

1.6 Significance of the Study

Study advances understanding of how rainfall and climate variability shape rural livelihoods by focusing on smallholder farmers who depend on seasonal rains. It brings human dimension beyond national statistics showing that rainfall shocks affect not only the quantity harvested but also the timing, diversity and reliability of foods households can access core dimensions of food security. Findings challenge assumption that higher agricultural output automatically ensures food security and instead point to interventions that address seasonal access and year-round stability.

Practically the study offers localized evidence for planners and NGOs working in rural Zambia to tailor ward level actions such as crop diversification, early-warning systems and resilience-building practices. It strengthens theories of

vulnerability and sustainable livelihoods and provides comparative data on environment.

1.7 Theoretical Framework

This study is guided by the Sustainable Livelihoods Framework (SLF), which offers a clear way to understand how rural households manage risks and build resilience to shocks like rainfall variability. In this study rainfall, variability is seen as an external stressor that affects crop productivity and threatens food security. The SLF explains how people use their natural, human and financial resources to maintain their livelihoods in the face of such challenges. It helps analyze how smallholder farmers adapt by changing decisions, reallocating resources, and developing new coping strategies. A livelihood is considered sustainable when it can recover from shocks, maintain assets and create long-term opportunities for the next generation. The framework also highlights the links between household responses, institutions and vulnerability allowing for a deeper understanding of how rainfall changes influence both physical outcomes and social or economic behaviors such as migration or changes in diet.

Climate Vulnerability Framework complements this approach by showing how exposure, sensitivity and adaptive capacity shape a household's vulnerability to climate shocks. Exposure refers to how much a household experiences climate events like irregular rainfall, sensitivity measures dependence on rain-fed farming and adaptive capacity reflects the ability to adjust or recover. Studies in southern Africa show that high sensitivity and low adaptive capacity increase food insecurity under climate stress.

2. Literature Review

2.1 Overview

FAO (2022a) report defines climate variability as the variations in the mean state of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability) or to variations in natural or anthropogenic external forcing (external variability). Some scholars defined perceptions of farmers regarding the long-term changes in temperature and precipitation as farmers' ability to understand climate change phenomena based on their own knowledge. Several studies pointed out some factors that influence farmers' perceptions including farmers' age, education, farming experience and sometimes access to climate information among others (Gbetibouo 2019) and (Ndambiri *et al* 2023). IPCC (2017) [6] defined adaptation as a process of reducing damages or harm that are associated with extreme weather events such as floods, droughts, landslides, storms, etc. Adaptation includes all actions intended to respond to the existing or anticipated climatic stimuli and their impacts. Adaptation depends significantly on the adaptive capacity or adaptability of an affected system, region, or community to cope with the impacts and risks of climate change. The adaptive capacity of communities is determined by their socioeconomic characteristics. According to (Burton *et al* 2017) adaptive capacity is the potential or ability of a system, region or community to adapt to the impacts of climate change. Other scholars defined adaptation in terms of the actions or strategies that households and communities undertake to enhance resilience of vulnerable systems and reduce climate change associated damages in order to meet

their livelihood needs (Rennie and Singh 2016) and (Scheraga and Grambsch 2018).

Studies in specific areas have also stressed how different types of rain affect different places. For instance, Sulaiman and Ishaku (2021) found that rainfall variability had a bigger negative effect in sandy soil zones in northern Nigeria than in clay-rich areas. This is because sandy soil holds water less well. Their research showed how important micro-climatic conditions are in figuring out how changes in rainfall affect crop yields. It is important to understand this spatial dimension in order to create interventions that make people more resilient, like encouraging crop varieties that have staggered maturity periods or are resistant to drought. It is interesting that not all effects of changing rainfall are bad. Anwar *et al.* (2019) saw that in some parts of southern India, years with above average but well-distributed rainfall could lead to bumper harvests. However, they warn that more variability means that floods and droughts are more likely to happen in the same season, which makes it harder for farmers to make decisions. In many parts of Africa and Asia, it is becoming common for there to be both flooding at planting time and drought during flowering. This duality makes yield losses worse and calls for new ways of planting like split planting and intercropping, to lower the risk of losing all the crops.

The fact that rain is unpredictable makes things even worse because it makes it hard to store and keep things. Ampaire *et al.* (2020) [2] say that in Uganda, sudden and unseasonal rains during the time after harvest caused a lot of legumes and grains to be lost. Even though the crops had done well during the growing season, this made food less available. Most rural homes do not have good storage systems for dealing with spoilage caused by moisture, and the fact that rainfall patterns change makes it hard to know when to harvest, dry, and preserve food. Because of this, some families lose up to 30% of the food they harvest, which could have helped them eat a wider variety of foods and stay food secure during the dry months.

Rainfall patterns also affect livestock production, which is an important part of mixed farming systems' dietary diversity. Mulenga and Wineman (2021) wrote about how unpredictable rainfall in Zambia made it harder for pastures to grow back and for livestock to get water, which led to more deaths and less milk production. This had a direct impact on the amount of milk and meat available to eat in the house, which was especially bad for children's nutrition. They found that households where rainfall variability made it harder for livestock to provide food had much lower dietary diversity scores than households with more resilient livestock systems or access to off-farm income. These results suggest that changes in rainfall can affect nutrition in other ways, such as by disrupting food sources that do not come from crops.

Osbahe *et al.* (2011) have similar reports in their study from Southwest Uganda, in which farmers reported that the first season had shifted from a start during February to March and now ended in April rather than May. Meanwhile, they found the second season had shifted from a start in August to September and now ended in November rather than December. This is the case for Ghana where there are several studies only on farmers' perceptions of climate variability and change (Asante *et al.*, 2017, Codjoe and Owusu, 2011, Derkyi *et al.*, 2018, Kolley and Jones, 2015). For example, Kolley and Jones (2015) focused on only

farmer 21 perceptions to report that farmers perceived decreasing precipitation and increasing temperature in the Ketu north district of the Volta region in Ghana. Similar results are reported by others in South Africa (Elum *et al.*, 2017), and Ghana (Asante *et al.*, 2017, Derkyi *et al.*, 2018).

There is a limitation from this approach, in that it is then difficult to reflect on the implications of local perception for effective adaptation or potential mal-adaptations because it is not compared with patterns of actual climatic data, nor does it let the researcher reflect on what might be driving perception for some farmers when there are differences. Thus, it is important to review empirical studies that have explored perceptions of climate variability and change with local meteorological data. Empirically, several studies have used this approach in South Africa (Gandure *et al.*, 2013, Thomas *et al.*, 2007), Uganda (Osbahe *et al.*, 2011), Nigeria (Ayanlade *et al.*, 2017), Zimbabwe (Moyo *et al.*, 2012), and Ghana (Limantol *et al.*, 2016, Yaro, 2013).

Mamba (2016) found that more women as compared to men correctly perceived climate variability and change and argued that women play critical roles in agricultural activities in patriarchal societies allowing them to be closely connected to the environment around them. Singh *et al.* (2018) found in India that older farmers had clearer perceptions than younger farmers did. However, Singh *et al.* (2018) found no difference between male and female farmers' perceptions of water scarcity. Singh *et al.* (2018) did find that more female 23 farmers than male farmers indicated that they 'don't know' and suggests this could be due to differential access to and use of information between men and women.

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2.2 Establishment of research gaps

A study by the International Food Policy Research Institute (IFPRI) suggests that by 2050, real prices might increase by 87-106% for maize, 55-78% for rice and 54-58% for wheat, relative to the 2010 baseline, because of adverse climate change impacts (Nielsen and Reenberg, 2010). In terms of vulnerability and impacts, the most affected would be the poor who have inadequate or no purchasing power to procure food from market sources (Morton, 2007). Under these circumstances the poorest people who already use most of their income on food products, would have to sacrifice additional income to meet their food and nutritional requirements (WFP, 2013).

3. Research Methodology

The study used a descriptive research design that focused on observing existing conditions without changing any variables. Design was suitable for understanding real situations and was commonly applied in social and agricultural research. It helped show rainfall patterns had shifted over time and how these changes affected food availability and diet diversity among smallholder farmers. The approach allowed the researcher to describe how changes in rainfall influenced crop yields and the coping methods farmers used. The goal was to provide a clear picture of actual conditions rather than manipulate them.

Purposive sampling was used to select households that had farmed for at least five years since they were more likely to have experienced rainfall changes. Stratified sampling was also applied to ensure that different villages or zones within the ward were fairly represented. This combination helped reduce bias and reflected variations in farming conditions and household practices. Study involved 75 participants a manageable and representative number for descriptive research. This sample size provided enough data for meaningful comparisons between different household types while remaining within time and resource limits.

Structured questionnaires were the main tool for collecting both quantitative and qualitative data. They included closed and open-ended questions covering household demographics, crop yields, rainfall experiences, food access and coping strategies. Quantitative data were analyzed using descriptive statistics in SPSS while thematic analysis was used to interpret open-ended responses. Triangulation combined these data sources to strengthen validity and ensure findings were accurate and credible. Ethical principles guided every stage of the research. Participants gave informed consent, their privacy was protected and no identifying details appeared in reports. The study also obtained approval from relevant authorities to ensure fairness and respect for all participants.

4. Research Findings and Discussions

4.1 Presentation of results based the Background

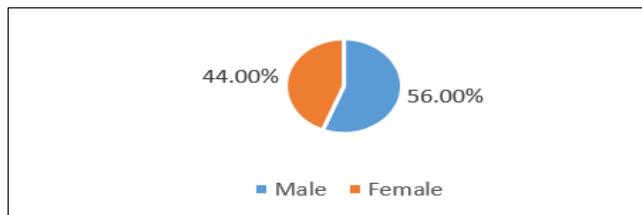


Table 4.1: Gender

Table 4.1 shows the gender distribution of respondents. The results indicate that 56% (42 respondents) were male, while 44% (33 respondents) were female. This suggests that a slightly higher proportion of male farmers participated in the study compared to female farmers. The dominance of male respondents could reflect gender dynamics in agricultural practices in Nkeyema Ward, where men often play a leading role in farming and decision-making related to land use and crop management.

Table 4.2: Age Group of Respondents

Variable	Observations (Obs)	Mean	Standard Deviation (Std. Dev.)	Minimum (Min)	Maximum (Max)
Age (years)	75	37.2	9.8	22	60

Table 4.2 presents descriptive statistics for the age of respondents. The results show that the average age of farmers in Nkeyema Ward was approximately 37.2 years, with a standard deviation of 9.8 years, suggesting moderate variation among respondents. The youngest participant was around 22 years, while the oldest was about 60 years. These results indicate that most farmers are within the productive working-age group capable of participating actively in agricultural labor and adaptation efforts. The mean age of 37.2 years reflects a relatively young farming population with potential to adopt innovative practices to cope with rainfall variability.

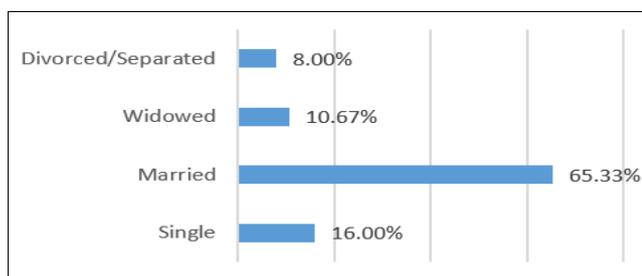


Table 4.3: Marital Status

As indicated in Table 4.3, the majority of respondents (65.33%) were married, followed by 16% who were single, 10.67% widowed, and 8% divorced or separated. The predominance of married respondents implies that most households in Nkeyema are family-based, with shared responsibilities in agricultural and domestic decision-making. Married individuals are also more likely to have access to family labor, which can enhance agricultural

productivity and resilience against the adverse impacts of rainfall variability.

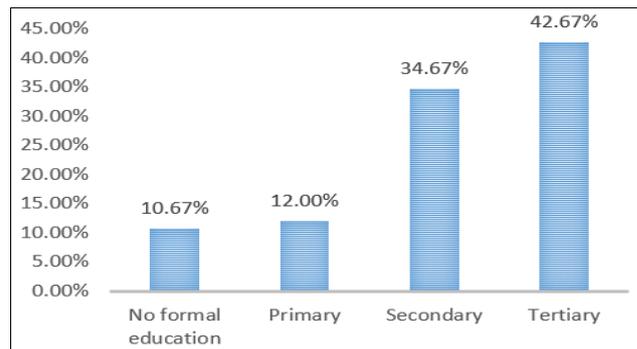


Table 4.4: Education Level

Table 4.4 illustrates the education levels of respondents. The results reveal that 42.67% (32 respondents) had attained tertiary education, 34.67% (26 respondents) had secondary education, 12% (9 respondents) had completed primary education, while 10.67% (8 respondents) had no formal education. This indicates that the majority of respondents had attained at least secondary-level education, suggesting a relatively literate farming community. Higher education levels are likely to contribute to improved awareness of climatic conditions, access to information and adoption of innovative farming methods that enhance household food security despite rainfall variability.

Table 4.5: Household Size

Variable	Observations (Obs)	Mean	Standard Deviation (Std. Dev.)	Minimum (Min)	Maximum (Max)
Household size (number of members)	75	5.8	2.3	2	11

Table 4.5 presents the descriptive statistics for household size among respondents. The results show that the average household comprised 5.8 members, with a standard deviation of 2.3, indicating some variation in family size across households. The smallest household had 2 members, while the largest had 11 members.

Table 4.6: Years of Farming Experience

Variable	Observations (Obs)	Mean	Standard Deviation (Std. Dev.)	Minimum (Min)	Maximum (Max)
Years of farming experience	75	7.4	3.8	1	18

Table 4.6 presents the descriptive statistics for the respondents' years of farming experience. The results show that the average farming experience was approximately 7.4 years, with a standard deviation of 3.8 years, indicating moderate variation among respondents. The least experienced farmers had about 1 year of experience, while the most experienced had up to 18 years in farming. 4.1.7 Farm size (hectares):

Table 4.7: Farm Size of Respondents

Variable	Observations (Obs)	Mean	Standard Deviation (Std. Dev.)	Minimum (Min)	Maximum (Max)
Farm size (hectares)	75	4.6	1.7	1	13.0

Table 4.7 presents the descriptive statistics for farm size among respondents. The findings show that the average farm size was approximately 4.6 hectares with a standard deviation of 1.7 hectares indicating some variation in land ownership across the sample. The smallest farm recorded was 1 hectare while the largest was about 13 hectares.

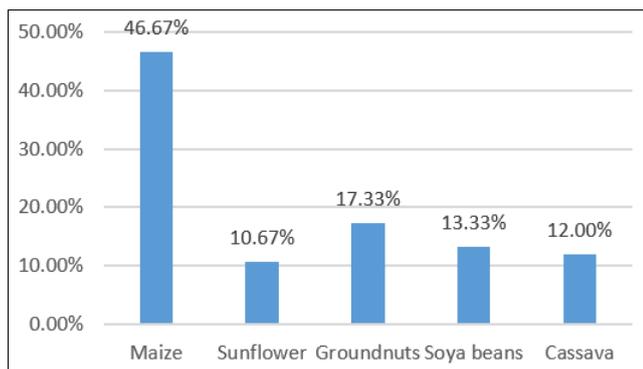


Table 4.8: Source of Water for Farming

As shown in Table 4.8, the majority of respondents (46.67%) reported maize as their main crop, followed by groundnuts (17.33%), soya beans (13.33%), cassava (12%), and sunflower (10.67%). This finding highlights maize as the dominant crop cultivated by smallholder farmers in Nkeyema Ward.

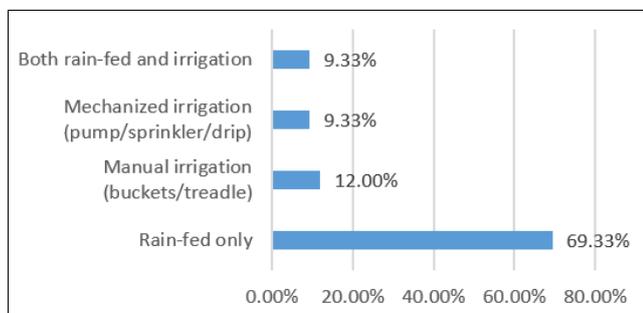


Table 4.9: Source of water for farming

Table 4.9 presents the sources of water used by farmers for crop cultivation. The findings reveal that 69.33% (52 respondents) relied solely on rain-fed agriculture, while 12% (9 respondents) used manual irrigation methods such as buckets or treadle pumps. About 9.33% (7 respondents) used mechanized irrigation systems, and another 9.33% (7 respondents) combined both rain-fed and irrigation methods.

4.2 Presentation of results based the Rainfall Variability and Crop Yield

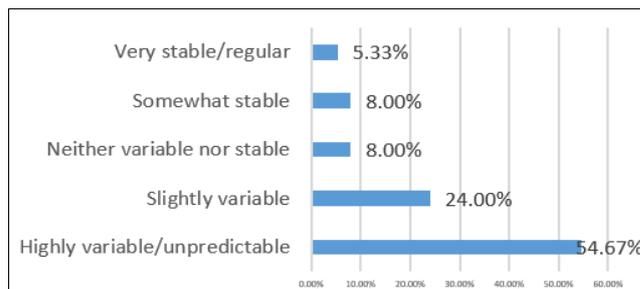


Table 4.10: Description of Rainfall Patterns in the Past Five Years

Table 4.10 shows respondents' perceptions of rainfall patterns in Nkeyema Ward over the last five years. The results indicate that 54.67% (41 respondents) described the rainfall pattern as highly variable or unpredictable, while 24% (18 respondents) considered it slightly variable. Only 8% (6 respondents) viewed it as neither variable nor stable, 8% (6 respondents) saw it as somewhat stable, and just 5.33% (4 respondents) reported it as very stable or regular.

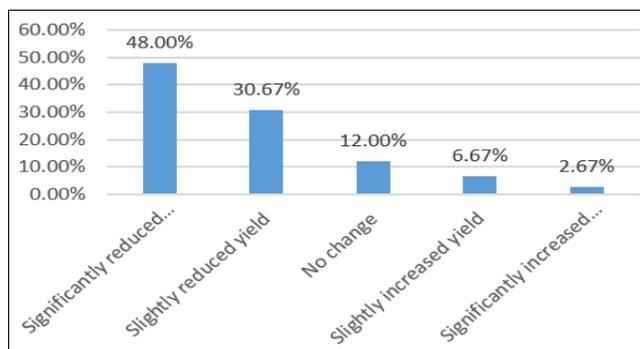


Table 4.11: Effect of Seasonal Rainfall Variability

As presented in Table 4.11, nearly half of the respondents (48%, representing 36 individuals) indicated that seasonal rainfall variability significantly reduced their crop yields. Another 30.67% (23 respondents) reported a slight reduction in yield, while 12% (9 respondents) observed no change. Only 6.67% (5 respondents) experienced slight increases, and a minimal 2.67% (2 respondents) reported significant increases in yield.

Table 4.1: Chi-Square Test on the Relationship between Source of Water for Farming and Effect of Rainfall Variability on Crop Yield

Q9 Source of water for farming:	Q11 How has seasonal rainfall variability affected your crop yield?					Total
	No change	Signifi..	Signifi..	Slightl..	Slightl..	
Both rain-fed and i..	0	0	6	1	0	7
Manual irrigation	3	0	3	0	3	9
Mechanized irrigation	0	0	4	0	3	7
Rain-fed only	6	2	23	4	17	52

Figure 4. 1 Source of Water for Farming and Effect of Rainfall Variability

Pearson chi2 (12) = 13.0752 Pr = 0.0364

Figure 4.1 presents the Chi-square test results examining the relationship between the source of water for farming and how seasonal rainfall variability affected crop yield among smallholder farmers in Nkeyema Ward. The analysis shows a statistically significant association between the two variables, with a Pearson Chi-square value of 13.08 and a p-value of 0.0364, which is less than the 0.05 significance level. This result indicates that the type of water source used for farming influences how rainfall variability affects crop yields.

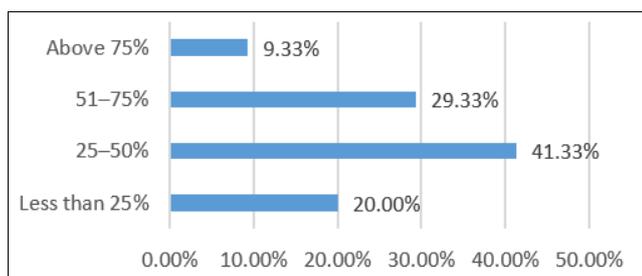


Table 4.12: Estimated Crop Yield Loss

Table 4.12 presents estimates of yield loss during irregular rainfall years. About 41.33% (31 respondents) reported yield losses ranging between 25–50%, while 29.33% (22 respondents) experienced losses between 51–75%. Another 20% (15 respondents) reported losses of less than 25%, and 9.33% (7 respondents) indicated losses above 75%.

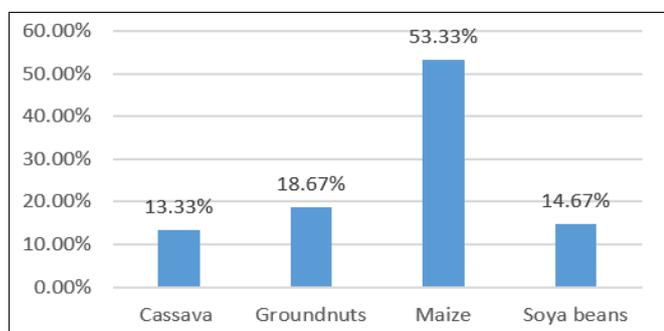


Table 4.13: Crops Most Affected by Rainfall Variability

Table 4.13 indicates that maize was identified by 53.33% (40 respondents) as the crop most affected by rainfall variability, followed by groundnuts at 18.67% (14 respondents), soya beans at 14.67% (11 respondents), and cassava at 13.33% (10 respondents).

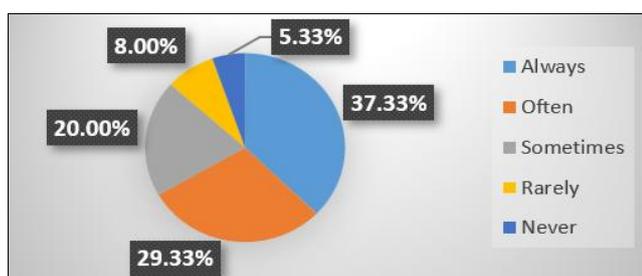


Table 4.14: Changes in Timing of Planting and Harvesting

As shown in Table 4.14, 37.33% (28 respondents) stated that they always notice changes in planting and harvesting timing due to rainfall variations, while 29.33% (22 respondents) said they often do. Another 20% (15 respondents) reported sometimes experiencing such changes, 8% (6 respondents) rarely noticed them, and only 5.33% (4 respondents) never did.

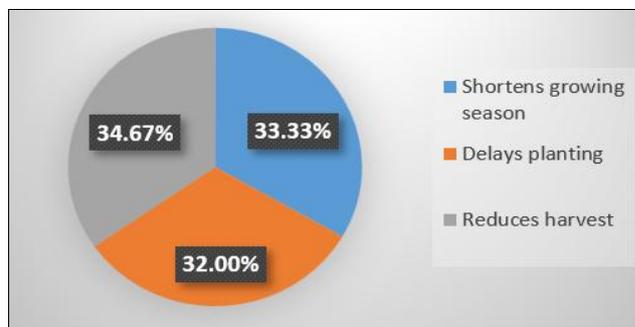


Table 4.15: Late or Early-Ending Rains

Table 4.14 presents the farmers’ experiences with late or early-ending rains. The findings show that 34.67% (26 respondents) said such rainfall patterns reduce harvests, 33.33% (25 respondents) noted that they shorten the growing season, and 32% (24 respondents) stated that they delay planting.

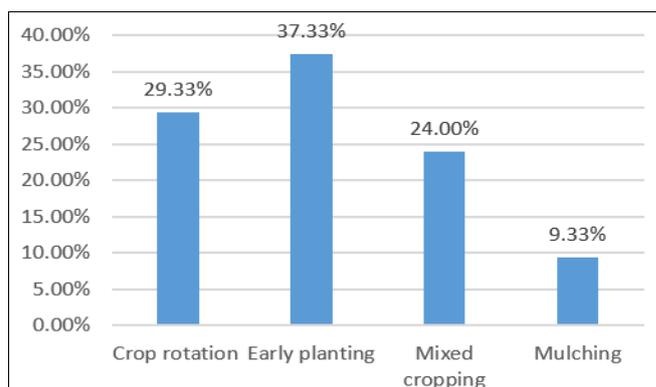


Table 4.16: Farming Practices Adjusted Due to Rainfall Variability

Table 4.15 illustrates the farming practices that respondents have adjusted in response to rainfall variability. The findings show that 37.33% (28 respondents) adopted early planting, 29.33% (22 respondents) practiced crop rotation, 24% (18 respondents) engaged in mixed cropping, while 9.33% (7 respondents) used mulching as an adaptive measure.

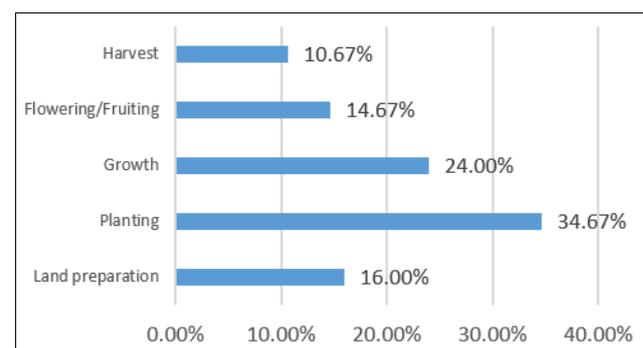


Table 4.17: Stages of Crop Production Most Vulnerable

As shown in Table 4.17, 34.67% (26 respondents) identified the planting stage as the most vulnerable to rainfall variability, followed by 24% (18 respondents) who mentioned the growth stage, 16% (12 respondents) who cited land preparation, 14.67% (11 respondents) who pointed to flowering or fruiting, and 10.67% (8 respondents) who mentioned harvesting.

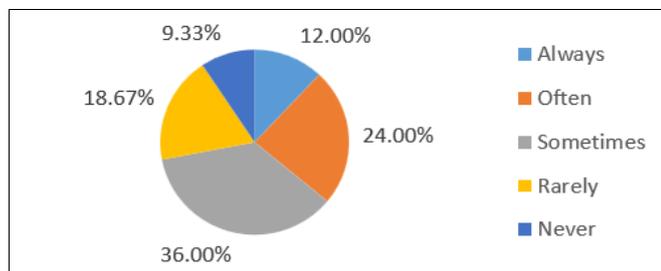


Table 4.18: Access to Rainfall and Climate Information

Table 4.18 presents findings on farmers' access to rainfall or climate information for planning purposes. The results show that 36% (27 respondents) reported receiving such information sometimes, 24% (18 respondents) said they receive it often, 18.67% (14 respondents) said rarely, 12% (9 respondents) said always, while 9.33% (7 respondents) said they never receive it.

4.3 Presentation of results based the Household Food Availability and Dietary Diversity

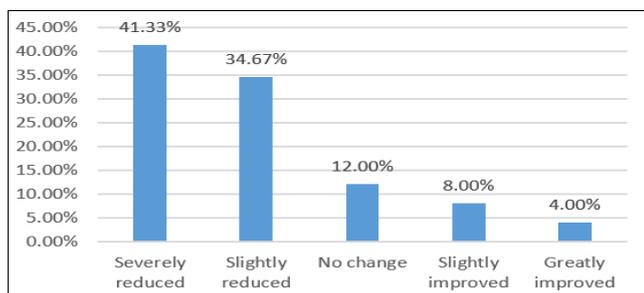


Table 4.19: Food availability in your household

Table 4.19 presents respondents' views on how rainfall variability has influenced food availability in their households. The results reveal that 41.33% (31 respondents) reported that rainfall variability has severely reduced household food availability, while 34.67% (26 respondents) said it slightly reduced it. A smaller proportion, 12% (9 respondents), observed no change, 8% (6 respondents) indicated that food availability slightly improved, and only 4% (3 respondents) reported that it greatly improved.

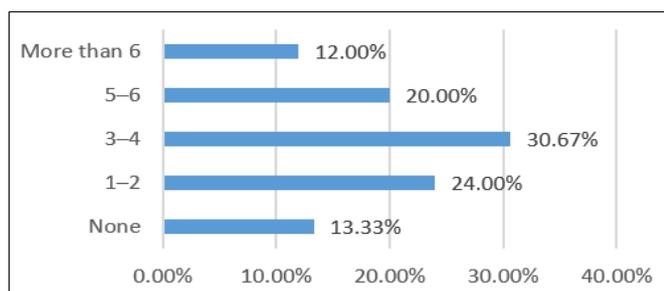


Table 4.20: Months of Food Shortages Experienced per Year

Table 4.20 shows that 30.67% (23 respondents) experience food shortages lasting 3–4 months each year, while 24% (18 respondents) face shortages for 1–2 months. Another 20% (15 respondents) reported shortages of 5–6 months, and 12% (9 respondents) experienced shortages for more than six months annually.

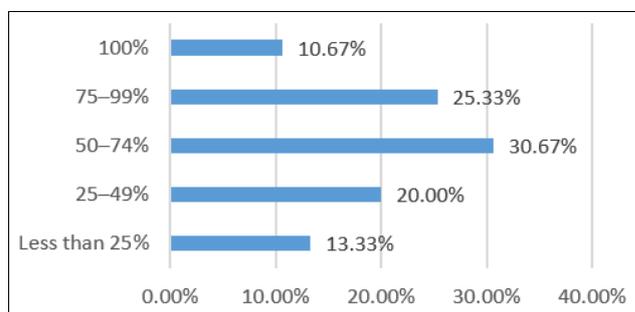


Table 4.21: Proportion of Household Food Sourced

As indicated in Table 4.21, the majority of respondents depend heavily on their own farms for food. About 30.67% (23 respondents) stated that 50–74% of their food comes from their own production, 25.33% (19 respondents) reported 75–99%, and 20% (15 respondents) said 25–49%. A smaller proportion, 13.33% (10 respondents), obtain less than 25%, while 10.67% (8 respondents) rely entirely (100%) on their own farm output.

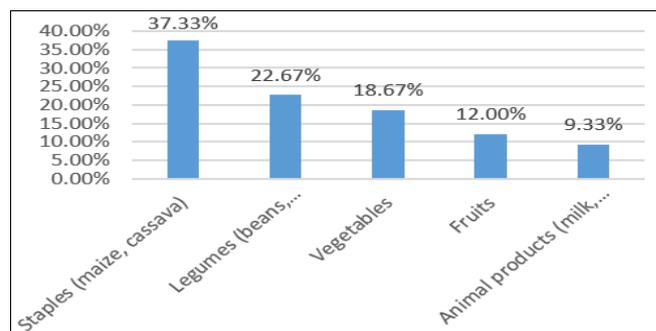


Table 4.22: Food Groups Most Affected by Rainfall Variability

Table 4.22 presents the types of food groups most affected by rainfall variability. The findings indicate that staple foods such as maize and cassava were most affected, cited by 37.33% (28 respondents). Legumes (beans, groundnuts, and soya beans) were reported by 22.67% (17 respondents), followed by vegetables at 18.67% (14 respondents), fruits at 12% (9 respondents), and animal products (meat, milk, and eggs) at 9.33% (7 respondents).

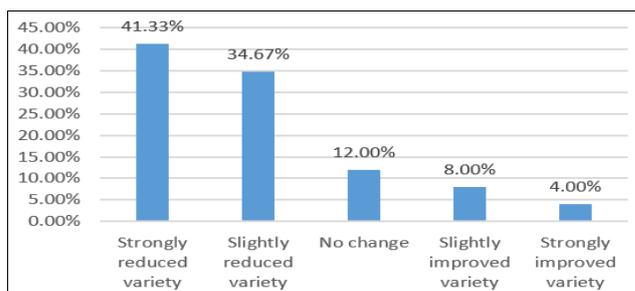


Table 4.23: Influence of Rainfall Variability on Dietary Diversity

As shown in Table 4.23, 41.33% (31 respondents) reported that rainfall variability has strongly reduced their household's dietary diversity, while 34.67% (26 respondents) said it slightly reduced it. Only 12% (9 respondents) reported no change, 8% (6 respondents) indicated a slight improvement, and 4% (3 respondents) noted a strong improvement in dietary variety.

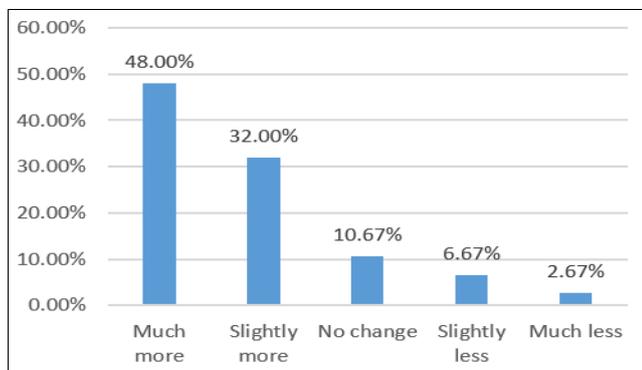


Table 4.24: Food Purchases during Poor Rainfall Seasons

Table 4.24 presents data on whether households purchase more food from markets during poor rainfall seasons. The findings indicate that 48% (36 respondents) reported buying much more food from markets, while 32% (24 respondents) said they purchased slightly more. 10.67% (8 respondents) observed no change, 6.67% (5 respondents) said they bought slightly less, and only 2.67% (2 respondents) reported buying much less food.

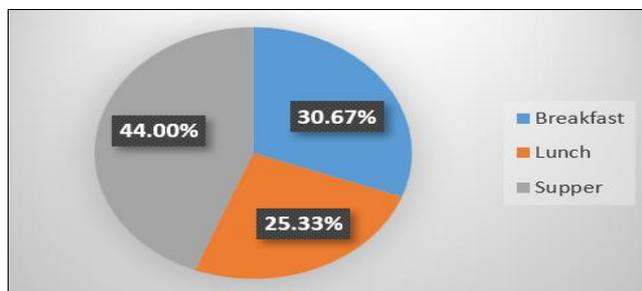


Table 4.25: Meals Most Reduced During Food Shortages

Table 4.25 shows which meals are most commonly reduced when households experience food shortages. The results reveal that supper was the most affected, reported by 44% (33 respondents), followed by breakfast at 30.67% (23 respondents) and lunch at 25.33% (19 respondents). This pattern suggests that during times of scarcity, families prioritize meals consumed earlier in the day and cut back on evening meals to stretch limited food supplies. The reduction of supper may have nutritional implications especially for children and elderly members who require regular intake.

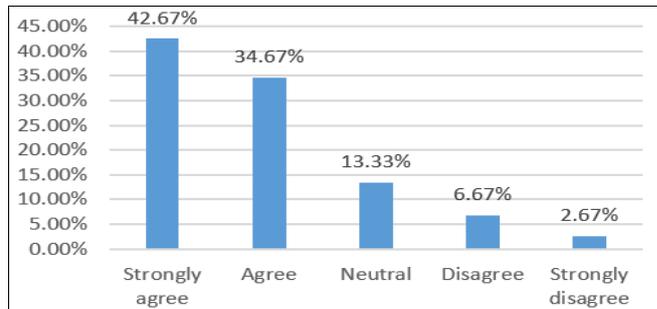


Table 4.26: Increased Dependence on External Food Aid

As presented in Table 4.26, 42.67% (32 respondents) strongly agreed and 34.67% (26 respondents) agreed that rainfall variability has increased their household's dependence on external food aid or support. Meanwhile, 13.33% (10 respondents) remained neutral, 6.67% (5 respondents) disagreed, and 2.67% (2 respondents) strongly disagreed.

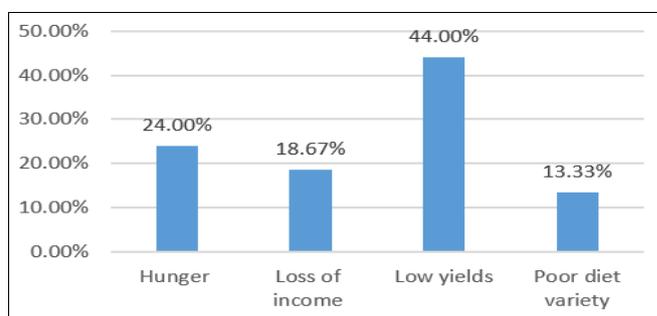


Table 4.27: Most Serious Effects of Rainfall Variability

Table 4.27 identifies what respondents considered the most serious consequences of rainfall variability on household food security. The majority, 44% (33 respondents), cited low crop yields as the most critical impact, followed by hunger at 24% (18 respondents) loss of income at 18.67% (14 respondents) and poor diet variety at 13.33% (10 respondents).

4.4 Presentation of results based the Coping and Adaptation Strategies

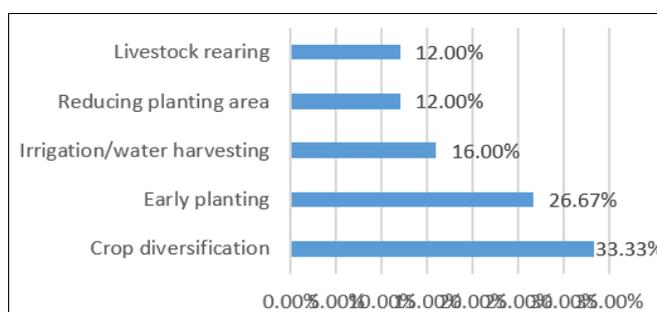


Table 4.28: Coping Strategies Adopted by Farmers

Table 4.28 shows the coping strategies employed by respondents to address rainfall variability. The findings reveal that 33.33% (25 respondents) practiced crop diversification, 26.67% (20 respondents) engaged in early planting, 16% (12 respondents) used irrigation or water harvesting, and 12% (9 respondents each) resorted to livestock rearing or reducing planting area.

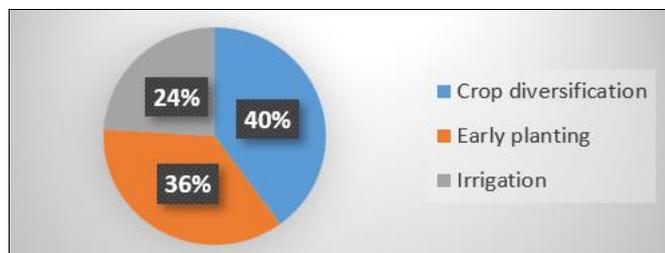


Table 4.29: Most Effective Coping Strategies

Table 4.29 presents farmers' views on which coping strategy has been most effective. The majority, 40% (30 respondents), identified crop diversification as the most effective approach, followed by early planting at 36% (27 respondents) and irrigation at 24% (18 respondents).

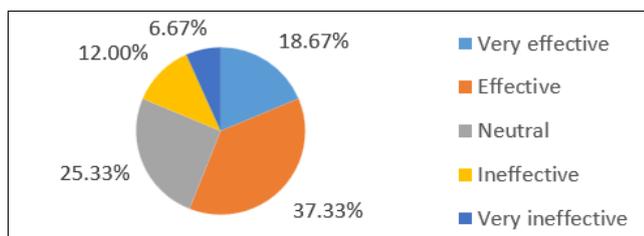


Table 4.30: Effectiveness of Current Adaptation Strategies

As shown in Table 4.30, 37.33% (28 respondents) rated their current adaptation strategies as effective, while 18.67% (14 respondents) considered them very effective. A further 25.33% (19 respondents) remained neutral, 12% (9 respondents) viewed them as ineffective, and 6.67% (5 respondents) described them as very ineffective.

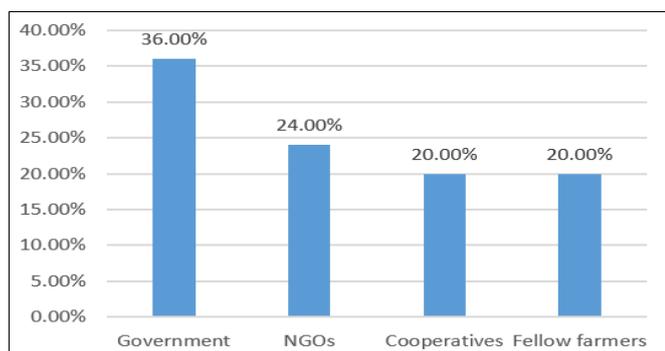


Table 4.31: Sources of Support for Adaptation

Table 4.32 presents information on the main sources of support received by respondents. The findings reveal that government agencies were the dominant source of assistance, cited by 36% (27 respondents). Non-governmental organizations (NGOs) followed at 24% (18 respondents), while cooperatives and fellow farmers each accounted for 20% (15 respondents).

Fig 4.2: Support Received and Effectiveness of Adaptation Strategies

Q31 Have you received support (training, inputs, extension services) to adapt to	Q30 How effective are your current adaptation strategies in addressing rainfall					Total
	Effective	Ineffec..	Neutral	Very ef..	Very in..	
Never	7	0	0	2	1	10
Often	4	3	7	3	1	18
Rarely	4	3	2	3	3	15
Sometimes	10	2	8	5	0	25
Very often	3	1	2	1	0	7
Total	28	9	19	14	5	75

Figure 4.2 presents the Chi-square test results examining the relationship between whether farmers received support to adapt to rainfall variability and the effectiveness of their current adaptation strategies. The analysis yielded a Pearson Chi-square value of 18.86 with a p-value of 0.0276, indicating a statistically significant relationship at the 0.05 level. This finding suggests that the level of support farmers receive such as training has a measurable influence on how effective their adaptation strategies are.

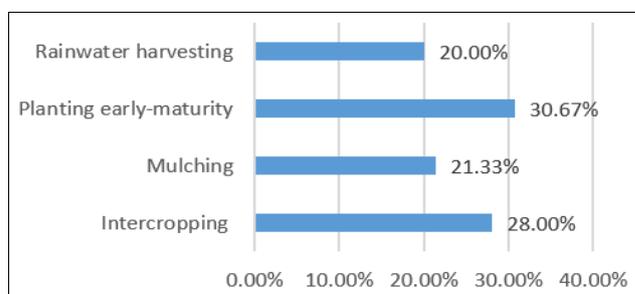


Table 4.32: Traditional and Indigenous Methods Used to Manage Rainfall Variability

As shown in Table 4.33, smallholder farmers continue to rely on traditional or indigenous coping practices alongside modern techniques. About 30.67% (23 respondents) reported planting early-maturing crops, 28% (21 respondents) practiced intercropping, 21.33% (16 respondents) used mulching, and 20% (15 respondents) employed rainwater harvesting.

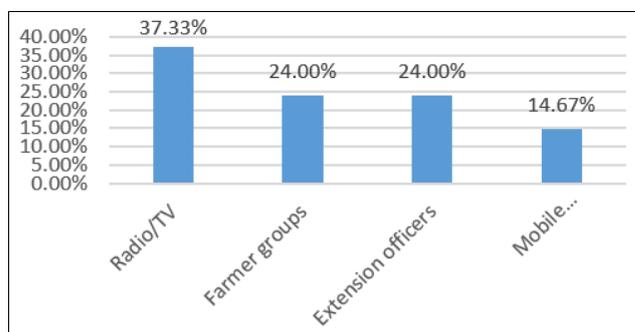


Table 4.33: Sources of Information on Rainfall and Farming

Table 4.34 shows how respondents usually access information related to rainfall and farming. The majority, 37.33% (28 respondents), reported that they obtain information through radio or television, while 24% (18 respondents) rely on extension officers and an equal 24% (18 respondents) on farmer groups. Another 14.67% (11

respondents) access information via mobile phones or the internet.

Table 4.35 presents the results of a simple linear regression analysis conducted to determine how years of farming experience and farm size influence the effectiveness of adaptation strategies among smallholder farmers in Nkeyema Ward.

Table 4.34: Regression Results for Adaptation Strategy Effectiveness

Predictor Variable	Coefficient (β)	Std. Error	t-Statistic	p-Value
Constant	2.145	0.321	6.68	0.000
Years of Farming Experience (Q6)	0.058	0.024	2.42	0.018
Farm Size (hectares) (Q7)	0.097	0.033	2.94	0.005

R² = 0.286 Adjusted R² = 0.264 F(2,72) = 14.42 p < 0.001

The regression model in Table 4.39 shows a statistically significant relationship between the selected predictors and the effectiveness of adaptation strategies (F(2,72) = 14.42, p < 0.001). The model explains about 28.6% of the variance (R² = 0.286) in perceived adaptation effectiveness among smallholder farmers.

The results indicate that both years of farming experience and farm size positively and significantly predict the effectiveness of adaptation strategies. The coefficient for years of farming experience (β = 0.058, p = 0.018) suggests that farmers with more years of experience are better able to identify and sustain adaptation measures to mitigate the effects of rainfall variability.

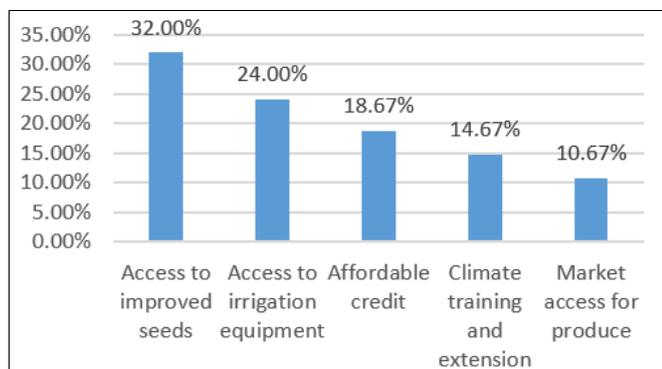


Table 4.35: Support Needed to Cope with Rainfall Variability

As shown in Table 4.36, the majority of respondents (32%, or 24 participants) identified the need for improved seeds as their most urgent support requirement. This was followed by irrigation equipment at 24% (18 respondents), credit access at 18.67% (14 respondents), climate training at 14.67% (11 respondents), and market access at 10.67% (8 respondents).

5. Conclusion and Recommendation

5.1 Conclusion

The study showed that rainfall variability threatened food security in Nkeyema Ward. 54.67% of respondents reported late starts or early endings to the rains, which disrupted planting and harvest timing. Nearly 48% said yields fell during erratic seasons, with maize most affected at 53.33%. Shorter wet seasons led to postponed planting and early crop drying. Access to irrigation reduced losses as shown by a significant link between water source and yield outcomes (χ²

= 13.08, p = 0.036). Productivity was tightly tied to rainfall and rain-fed systems remained highly vulnerable. Farmers used coping measures still results varied. 33.33% and early planting reported crop diversification by 26.67%. Larger farms and longer experience improved adaptation effectiveness (p < 0.05). Support mattered too as effectiveness rose with training, inputs or extension services (χ² = 18.86, p = 0.028), though 13.33% never received help and 33.33% only sometimes did. Information gaps persisted with 24% relying on extension agents and 37.33% on radio often with delays. Since 69.33% depended only on rain-fed agriculture the study recommended small-scale irrigation, better local forecasts and mobile alerts, drought-tolerant seed access and stronger consistent extension support.

5.2 Recommendation

The study recommended several actions to strengthen resilience against rainfall variability. Expanding small-scale irrigation and water harvesting was key as most farmers still depended on rain-fed agriculture. Simple systems such as treadle pumps, solar-powered schemes and community reservoirs could help reduce crop losses and stabilize food supplies year-round. Access to credit, inputs, and reliable markets also needed improvement. Flexible credit programs and targeted input support for vulnerable households would enable the purchase of improved seeds and fertilizers while stronger market linkages could balance income and food access during both good and poor seasons. Improving the flow of climate information and strengthening extension services were also vital. Collaboration among government agencies, NGOs and local communities should be improved to avoid duplication and ensure consistent support. Training on climate-smart farming was recommended to build farmers' skills and confidence in adapting to shifting rainfall patterns.

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