The Role Of Orphan Crops In Enhancing Food Security In Kibwezi West Sub-County, Kenya

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Abstract

Climate variability and change pose significant threats to agricultural productivity in semi-arid regions where rainfall is erratic and droughts are frequent. This study was carried out in the semi-arid Kibwezi West Sub-County and investigated the role of three orphan crops namely: green gram, sorghum, and pigeon pea in promoting food security under challenging climatic conditions. Meteorological data for Kibwezi West Sub-County was obtained from the Kenya Meteorological Department Headquarters while data on the role of orphan crops in promoting food security was obtained through field surveys using in-depth interviews, questionnaires and observation methods. This study had a sample size of 275 households that were selected through the simple random sampling technique. The findings revealed that Kibwezi West Sub-County experiences significant rainfall anomalies and pronounced drought cycles that occur once every two years for both the long and short rains. The short rainfall season demonstrated higher rainfall totals but increased drought risks prompting famers to grow drought-tolerant orphan crops. Analysis of orphan crop performance demonstrated remarkable resilience, with green gram showing exceptional drought tolerance and consistent yields, pigeon peas exhibiting moderate climate adaptability, and sorghum displaying a distinct drought response pattern. Crop adoption varied, with 17.5% of the households growing all three orphan crops, 44.2% growing two and 38.3% growing only one of the three. The two most commonly grown orphan crops were green gram and pigeon peas. Green gram was the most promising crop, characterized by fast maturity, high yields, and exceptional drought tolerance. By providing food and an income source that is used to purchase other foods, orphan crops offer a sustainable strategy to enhance food availability, stability and accessibility in the face of increasing climate uncertainties. These crops also promote food utilization by offering nutritious alternatives to mainstream crops that have become overly sensitive to climate variability and change.

Keywords: Orphan crops, food security, climate variability and change, drought resilience, smallholder farming.

1. Introduction

Food security has remained a global challenge despite efforts to identify and implement policies that will help curb this menace, such as improved food distribution and increased agricultural production. Estimates show that nearly two billion people globally face moderate to acute food shortages (UNICEF, 2019), with climate variability and change a significant cause of food insecurity in various parts of the world (Gebre et al., 2025). Orphan crops are those crops that either originate from a specific locality or have become indigenized through several years of growing, natural selection and farmer selection (Mabhaudhi et al., 2019; Chongtham et al., 2022). The potential of these crops under water scarcity is crucial in global food security and may contribute to sustainable food systems amidst climate change (Babele et al., 2022). For instance, farmers in India are now switching to millet farming after the water-guzzling paddy and wheat face tough challenges with the increasing temperatures, and reduced rainfall threatening food security (Maitra, 2020).

Climate variability and change have been blamed for the higher-than-average level of food insecurity in East Africa compared to other regions of the world (Gebre, 2021). In Ethiopia for instance, Shekuru et al. (2022) note that climate variability in the North Shewa Zone is the biggest challenge to food production, leading to increasing annual production losses. However, Ethiopia can achieve food security with the help of orphan crops such as enset which can feed one hundred million people (Ashebir, 2022), and therefore the most sustainable approach to reducing and controlling food insecurity in Ethiopia's drought-prone regions is to promote and conduct research on orphan crops (Santhoshini et al., 2025).

Kenya is listed globally as a low-income country with a food deficit (UNICEF, 2020). In Makueni County, Kibwezi West Sub-County in particular, there has been a decline in agricultural production attributed to low and unreliable rainfall (Lubajo, 2022). According to Abuya (2021), increasing temperatures and reduced rainfall in the Sub-County have negatively impacted food production with maize and beans cultivation the most affected. As a result, Nzioka et al. (2022) suggest that farmers in the area switch to crops such as sorghum and green grams which are not only drought tolerant but also resilient to many tropical pests and diseases. Unlike most staple crops, orphan crops are well adapted to harsh climatic conditions and require minimal agronomic practices hence a suitable solution to food insecurity in ASALs. In Kenya where over 2.7 million people in 23 of the 47 counties were estimated to be facing climate-related food insecurity (National Drought Management Agency, 2022), the role of orphan crops in enhancing food security cannot be underestimated. Farmers in ASALs of Kenya have traditionally grown orphan crops to cushion themselves against severe food shortages. Although studies on the role of orphan crops in enhancing food security are not limited, there is a need for area-specific studies due to varying perceptions and attitudes towards orphan crops as well as varying rainfall characteristics from one place to the other. It is against this background, that this study sought to examine and document the role of orphan crops in promoting food security in the Sub-County.

2. Methodology

2.1 Study Area

This study was conducted in Kibwezi West Sub-County, one of the six Sub-Counties of Makueni County in the southeastern part of Kenya. The county lies within Latitude 1°35' and 3°00' south and Longitude 37°10' and 38°30' east (Figure 1). The Sub-County has a total area of 1,184.2 Km² with a population of 197,000 persons and approximately 47,594 households (KNBS, 2019). Two major rainfall maxima are experienced in the area namely: the long rainfall season which is received in March, April and May (MAM) and the short rainfall season which is received in October, November and December (OND). The average annual rainfall is erratic; at 500mm. Small-scale farming is the principal economic activity in the Sub-County.

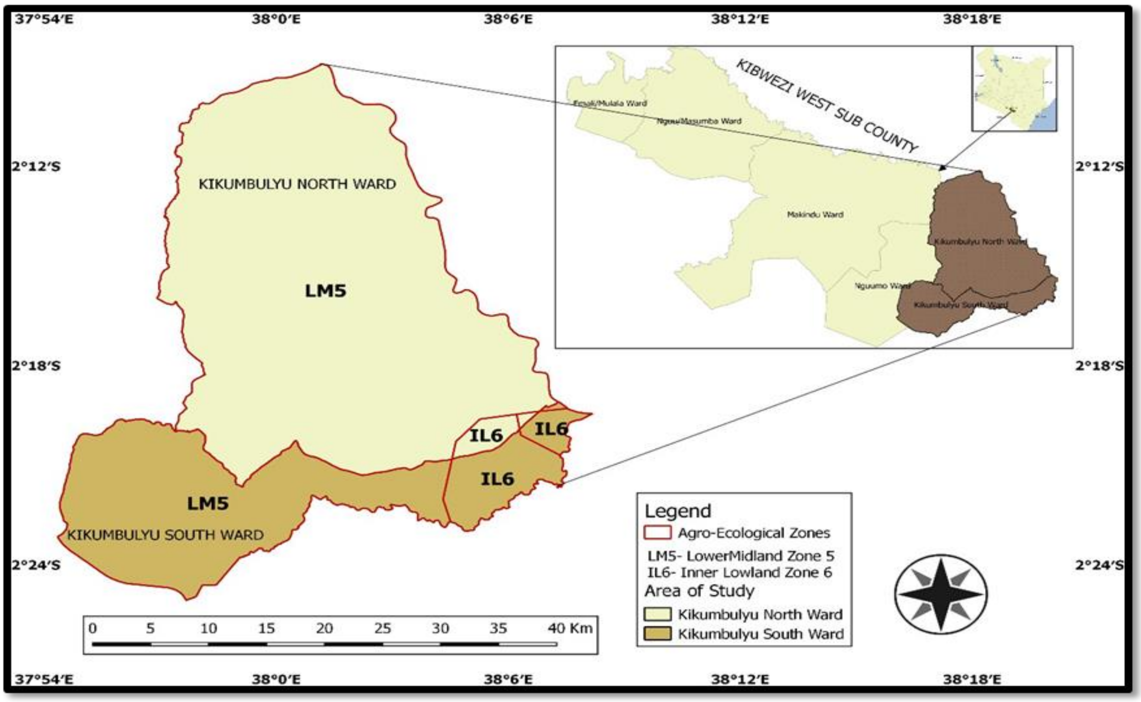

Figure 1: Map of Kibwezi West Sub-County Showing the Study Area

2.2 Data collection

Rainfall data for Kibwezi West Sub-County was obtained from the Kenya Meteorological Department Headquarters for the period 1993-2023. Three orphan crops namely: green gram, sorghum and pigeon peas were investigated. The three were purposively chosen because they are the most commonly grown orphan crops by smallholder farmers in the area. Data on their role in promoting food security was obtained through field surveys using in-depth interviews, questionnaires and observation methods. This study had a sample size of 275 households that were selected through the simple random sampling technique. However, only 240 questionnaires were filled out and therefore used for this analysis.

2.3 Data analysis

The study analyzed the MAM and OND rainfall anomalies by subtracting the long-term seasonal mean from the annual seasonal rainfall total, variations using the Coefficient of variation (C.V), rainfall concentration using the Precipitation Concentration index (PCI) and linear regression for trend analysis. Climatologically, wet or dry climatic conditions occur when rainfall is above or below the long-term average respectively (Huho, 2017). Based on this definition, the years where the rainfall amount was below the seasonal long-term mean were considered dry seasons while those above the seasonal long-term mean were considered wet seasons. Content analysis was used to analyze qualitative data.

3. Results and discussions

3.1 Seasonal rainfall performance

Crop production in the study area is influenced by rainfall performance more than any other climatic element. Specifically, it is dependent on anomalies, variations, distribution and timings (Makokha & Obiero, 2021; Kiguhi et al., 2025). Rainfall anomalies are deviations of observed rainfall from a long-term average for a specific region and period (Sewagegn, 2024). Anomalies help indicate unusual weather patterns such as droughts or periods of excessive rainfall. The mean seasonal rainfall is the baseline (0) in Figure 2, therefore all the negative values represent dry seasons and the positive values portray wet seasons.

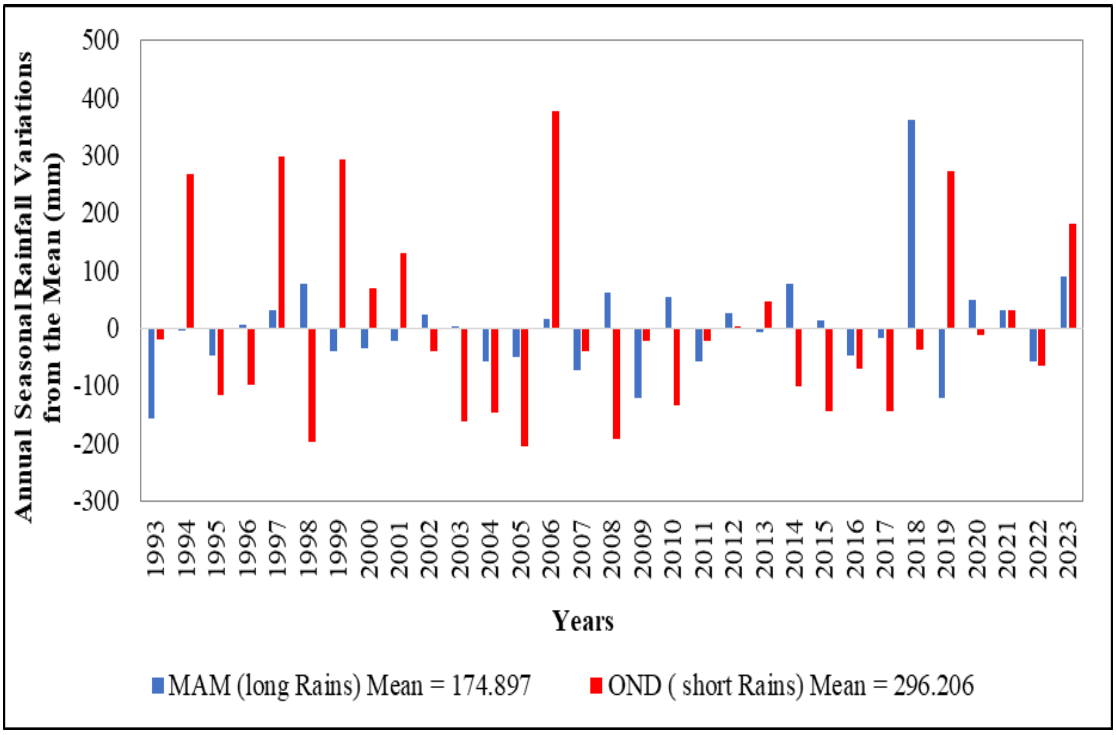

Figure 2: Seasonal Rainfall Anomalies

The MAM and OND seasons had long-term means of 174.9mm and 296.2mm respectively. Wet and dry climatic conditions occurred in 48% and 52% of the period for the MAM season and 35.5% and 64.5% of the same period for the OND season. While this translated into a drought cycle of once every two years in both seasons, the MAM season showed a near-equal rainfall distribution (48% wet and 52% dry) while the OND season had a pronounced dry bias (64.5% dry and 35.5% wet). This indicates that the OND season was more prone to prolonged dry spells which negatively impacted agricultural activities in the area. However, due to the season's higher rainfall totals, it was the primary crop-growing season. This was confirmed by 98% of the respondents who noted that they depended on the short rains for their farming activities, since the season received higher rainfall amounts. Nevertheless, with the season experiencing a higher frequency of droughts, the chances of crop failure were high and as a result, many smallholder farmers had turned to growing orphan crops. The coefficient of variation was used to determine the seasonal rainfall variation for both MAM and OND seasons using the formulae below.

$$cv = \frac{\sigma}{\bar{x}} * 100$$

Where:

σ = Standard deviation of the dataset

$\bar{x}$ = Mean of the dataset

The short rains had a C.V of 51% and a standard deviation of 89.2. This indicates that rainfall was highly variable fluctuating by +/- 89.2mm from the long-term mean, showing a substantial degree of drought risks in the Sub-County during the season. The long rainfall season had a C.V of 54% and a standard deviation of 160, indicating a higher degree of variability with rainfall amounts fluctuating by +/-160mm from the long-term mean. The short rains were therefore less variable and less slightly prone to drought or floods making them more reliable compared to the long rains.

3.2 Seasonal rainfall concentration

Rainfall concentration refers to the way rainfall is spread over a given area during the year or season (Nyika, 2022). The distribution of rainfall is central to rain-fed agriculture since an unbalanced distribution evokes periods of excess rainfall or drought which influence plant and crop growth. Seasonal rainfall concentration was established using the following formula.

$$PCI_{Seasonal} = \frac{\sum_{1=1}^{3} P_i^2}{\left(\sum_{1=1}^{3} p_i\right)^2} \times 25$$

Where P = the monthly precipitation in month *i* that is calculated for each year throughout the observation period. According to Kalisa et al. (2020), a PCI value of less than 10 indicates fairly evenly distributed rainfall, a value between 10 and 20 shows a moderate distribution where rainfall is concentrated in a few months within a year, while a value above 20 indicates irregular distribution. The MAM and OND seasons had PCI values of 9.9 and 11 respectively. This means that the MAM rainfall was distributed fairly uniformly while the OND rains were moderately distributed. The uniformity in the MAM rainfall implied a lower risk of extremely dry or wet conditions. The moderate concentration of OND rains indicates that the Sub-County was moderately at risk of floods or drought conditions during the season. However, while the MAM rains were distributed fairly uniformly, the rainfall amounts were very low to sustain crop production.

3.3 Seasonal rainfall trend

Seasonal rainfall trend was determined by plotting the changes and patterns of rainfall in the Sub-County over the past three decades (1993-2023). Figure 3 shows the MAM and OND rainfall trend.

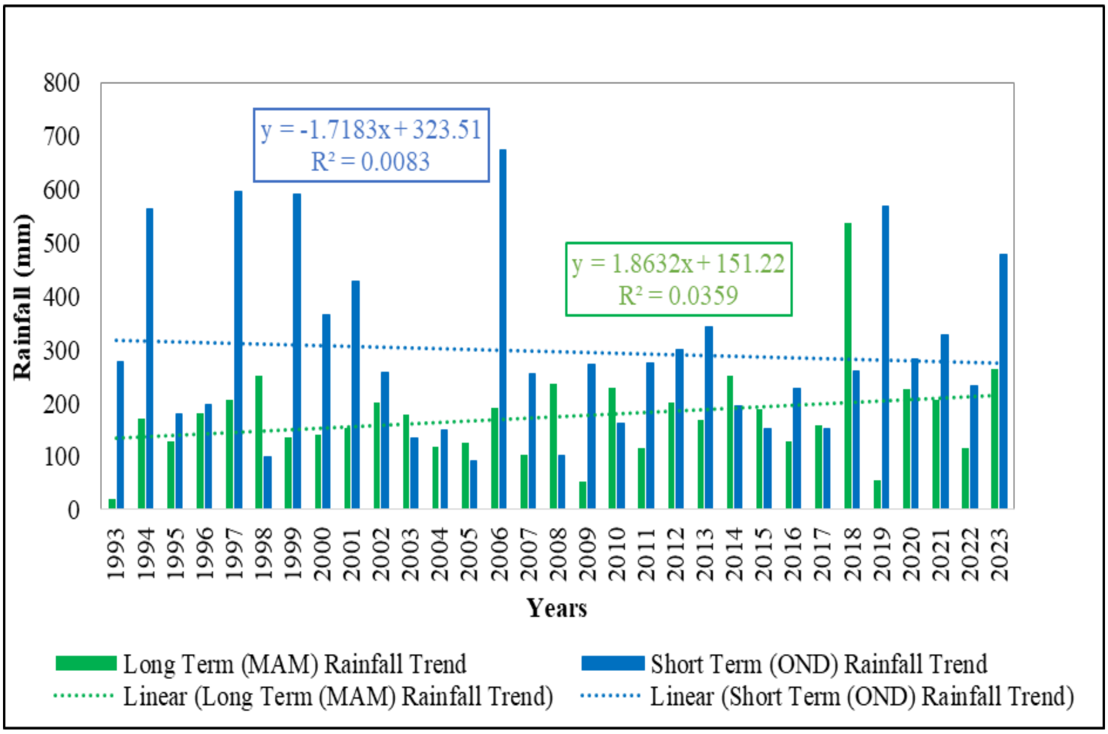

Figure 3: MAM and OND Rainfall Trend

The long rains showed an increasing trend while the short rains were decreasing (Figure 3). From the linear regression equations, the long rains were increasing at a rate of 1.9mm annually while the short rains decreased at a rate of 1.7mm every year. This signals a shift in seasonal rainfall trend, likely driven by climate change, consequently disrupting agricultural activities in the area. Given that the decreasing OND rains are the primary crop growing season, this necessitates a shift to drought-tolerant crops to maintain agricultural productivity and enhance food security in the area. Acknowledging the decreasing OND rains in Makueni County, Ndungu et al. (2022) note a decline in the length of the growing period during the short rains, a direct consequence of reduced rainfall amounts, further underscoring the urgency for adaptive agricultural strategies to promote food security.

4. Orphan Crop Performance in Relation to the OND Rains

Orphan crops refer to those crops that have either originated in a geographic location or have become ‘indigenized’ over many years (>10 decades) of cultivation as well as natural and farmer selection (Chongtham et al., 2022). In the face of climate variability and change, the potential of orphan crops is critical to global food security and may contribute to sustainable food systems (Babele et al., 2022). The commonly grown orphan crops in the area included pigeon pea, sorghum and green grams. While Sorghum is native to the area, green gram and pigeon peas are not native to Kenya. Green grams (mung beans) have their roots in Asia, particularly India, while pigeon peas originated in South Asia. However, the two have been successfully adopted by smallholder farmers in Makueni County due to their resilience and suitability for the region’s semi-arid climate. The performance of the three orphan crops against the OND rains (main crop growing season) was analyzed and the findings are presented in Figure 4.

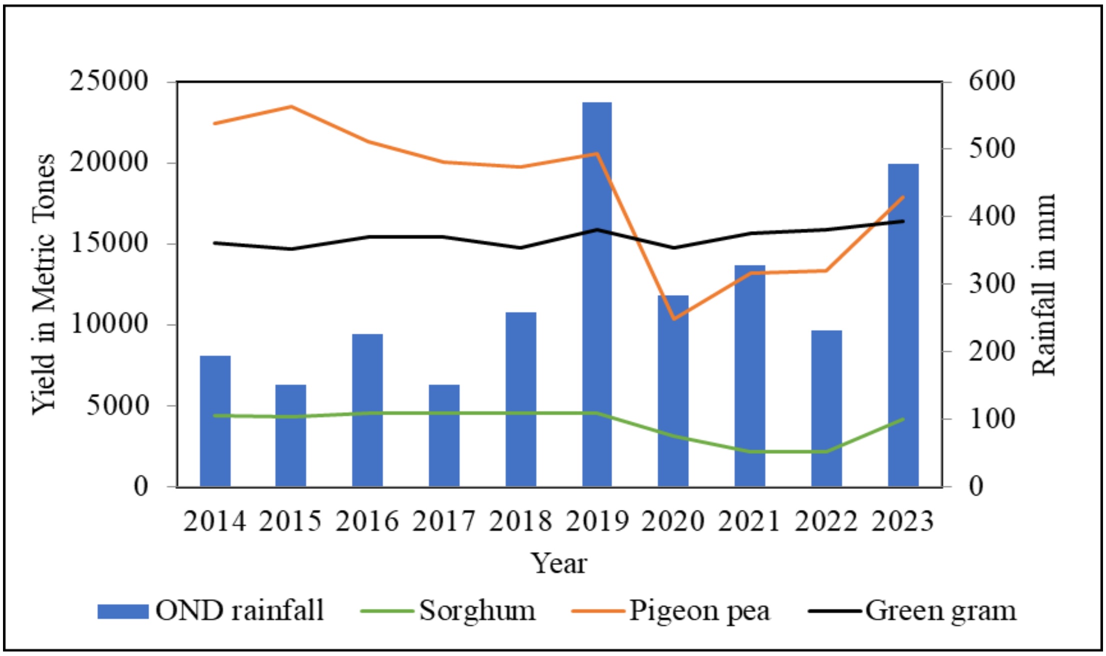

Figure 4: Annual OND Rainfall and Orphan Crop Yield

The yields of green grams demonstrated consistency in the face of notable fluctuations in rainfall. Despite the sharp rises and falls in rainfall amounts, yields were steady throughout the decade, ranging from 15,000 to 16,000 metric tonnes. This suggests excellent drought tolerance. As a result, some farmers had abandoned the growing of other crops to concentrate on green gram production (Figure 5). Similar findings were made by Mulika (2022) who notes in Kenya's ASALs, green gram is the second preferred grain after maize due to its drought tolerance characteristics and high yields.

Figure 5: *A green gram monoculture farm in Kikumbulyu South Ward*

Pigeon pea yields showed a moderate sensitivity to drought. In 2019 when rainfall was high pigeon pea yields were also high and when rainfall dropped in 2020 the yields dropped drastically. Between 2020 and 2023 when rainfall was increasing, pigeon pea yields also increased. However, it is noteworthy that of the three orphan crops, pigeon pea was the only crop that required both short and long rains for high yields. Its flowering period coincided with the long rains making these rains critical for optimal performance. This supports the findings by Ojwang (2023) who report that the low long rains are a major constraint to pigeon pea production, often resulting in flower abortion and consequently low yields. However, with the long rains increasing annually, pigeon pea production has steadily risen in recent years (Figure 6).

Figure 6: *Pigeon pea intercropped with maize. The maize has withered due to dry season*

Sorghum had the most intriguing drought response pattern. Surprisingly, sorghum yields declined between 2020 and 2022 as rainfall reduced, although its yields remained stable despite variations in rainfall between 2014 and 2018. This implied that sorghum had a drought tolerance threshold. According to Ondiko and Recha (2022), drought stress lowers yield by reducing sorghum height, panicle exertion, leaf size, and panicle length and height. Further research through household surveys, however, revealed that sorghum was the second most drought-tolerant after green gram, and the decreased yields were attributed to a decreasing number of farmers growing the crop because of its wrong perception as a staple for the underprivileged.

5. Orphan crops and food security

To determine their role in enhancing food security in the area, the study first found out how many of the three orphan crops each household grew. The analysis was done and the findings presented in Table 1.

Orphan Crops	Number of Households	Percentage
One	92	38.3
Two	106	44.2
All three	42	17.5
Total	**240**	**100.00**

Table 1: *Orphan Crops Grown by Households (Source: Field Data, 2024)*

Table 1 shows that 17.5% of the households grew all three orphan crops, the majority at 44.2% grew two, and 38.3% grew only one of the three. The two most commonly grown orphan crops were green gram and pigeon pea, with sorghum the least grown.

4.1 Sorghum

Sorghum was mainly grown during the short rains because the season experienced higher rainfall amounts. It was the least cultivated with only 25.8% (62) of the smallholder farmers having grown the crop in the previous season. The low adoption was mainly due to the perception that sorghum was food for the poor and animals. However, farmers noted that after green gram, sorghum was the second most drought-tolerant, disease-resistant and with the highest output per unit area. Due to its high tolerance to drought stress and its ability to do well under a wide range of tropical soils, Kazungu (2022) refers to the crop as the camel of the plant kingdom. A majority (48) of the farmers grew sorghum for sale or animal feeds with very few growing for household consumption. The few growing the crop for household consumption benefit from its high nutritional value, since the grain is rich in vitamins, carbohydrates and fiber (Mutua & Mwaura, 2024). I interviewed Sophie, a smallholder sorghum farmer at her home in Kikumbulyu South Ward, and with excitement she stated as follows:

"I harvested 4 bags of sorghum despite the low rains and have since sold two to buy food with the rest feeding my chicken. After harvesting, I store the sorghum stover to feed my goats, especially during the dry season when it's hard to find pasture".

This experience underscores the vital role sorghum plays in enhancing food security. With its high tolerance to drought, sorghum not only guarantees food availability but also enhances its stability by providing reliable harvests despite the changing climatic conditions. The sorghum stover is fed to livestock helping maintain condition and increase survival during the dry season. In turn, healthy animals contribute to food availability and accessibility through both the consumption and sale of livestock products. By selling part of her harvest, Sophie gains income to purchase additional food, further improving food accessibility for her household. These findings align with those of Mutua & Mwaura (2024) who observe that sorghum production improves the income of sorghum-producing households, consequently enhancing food security in Makueni County.

4.2 Green grams

Green gram was mostly grown during the short rains. Farmers noted that the long rainfall was extremely low hence less promising; explaining why the majority did not grow the crop during the season. For green gram, 76.7% (184) of the farmers had grown the crop while the few who had not cited a lack of funds to purchase seeds. Farmers noted that the crop was the most favorite in the area due to its fast maturity, high yields and high tolerance to drought and numerous tropical pests and diseases. Its high resilience to drought ensured consistent production even during periods of low rainfall, providing a reliable source of food, thus fostering food availability and stability. According to Muchomba et al. (2023), as a food crop, green gram is rich in minerals, vitamins and fiber essential in improving human nutrition and health. However, owing to its large market and high prices, a majority of farmers sold their produce giving them a steady income that enabled them to buy other foods, increasing their families' food accessibility. In conclusion, green gram proved to be the most suitable crop for the area, promoting food availability, accessibility, utilization and stability.

4.3 Pigeon pea

Pigeon pea was the second most grown crop in the area after green gram. The crop was grown by 67.9% (163) of the smallholder farmers. Most of those who had not grown (7) lacked the money to purchase seeds while a few (5) claimed that frequent droughts had significantly lowered yields discouraging them from growing. However, according to Ojwang (2023), the recent introduction of ICEAP 01552 (M-PESA) variety has given hope to pigeon pea farmers in the area due to its high yields and fast maturity period. This was confirmed by Mwangangi, a smallholder pigeon pea farmer in the area who noted the following:

"With the M-PESA variety, we no longer have to wait until July to harvest pigeon peas. They are available throughout the year. We use them to make sauces and also mix them with maize. However, the only challenge is that the seeds are expensive to purchase, limiting their accessibility to only a few farmers".

This highly drought-tolerant and high-yielding variety has increased the production of pigeon peas in recent years, and as a result, promoted food availability and stability in the area. It is worth noting that pigeon pea was the only orphan crop among the three that was consumed when green and dried. This, combined with its longer maturity period, resulted in an extended harvest period that corresponded with the dry season. According to Viteri & Linares-Ramírez (2023), the crops extended harvest period helps spread food production throughout the year warranting a more stable food supply, especially during the dry spell period. Some farmers harvested the crop twice a year by pushing the second harvesting period to December, January and February through ratooning. However, Ogero (2023) discourages prolonged ratooning claiming that it has the potential to accumulate and spread pests and diseases to other crops in subsequent seasons. Famers noted that apart from being a food crop, pigeon pea was also a source of income. According to the farmers, demand and market price for the crop was always high with most of them selling the crop while green when the demand and price were the highest. This improved farmers' income enabling them to purchase other food items hence promoting food accessibility.

5. Conclusion

The study established that the area experienced significant climate variability, including erratic rainfall and prolonged droughts. Further, smallholder farmers had continued to grow orphan crops with some completely abandoning the growing of staple crops like maize and beans. The three orphan crops played a vital role in promoting food security for the producing households, despite the seasonal rainfall variability. These crops not only provided food and animal feed but also served as a significant source of income when sold, thereby contributing to food availability, stability, and accessibility. They also promote food utilization by offering nutritious food alternatives to mainstream crops that have become overly sensitive to climate variability and change. This underscores the important role orphan crops play in enhancing both food security and economic stability for smallholder farmers in the area. Among these, green gram production was the most promising followed by sorghum and pigeon pea production. While pigeon pea benefits were undeniable, the high cost of seeds especially for the new drought-tolerant variety remained a major challenge, limiting their access to a few farmers who could afford them. These findings highlight the resilience of these crops to drought and their potential to stabilize food production in semi-arid regions.

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