Assessing Climate-Smart Agriculture Practices for Enhanced Food Security in Nyamira County, Kenya: A Scientific Perspective

Dennis O. Otwori[1], Edward M. Mugalavai[2] & Samuel S. China[3]

[1]*Department of Disaster Management and Sustainable Development, Masinde Muliro University of Science and Technology, Kenya (otwori92@gmail.com)*

[2]*Department of Disaster Management and Sustainable Development, Masinde Muliro University of Science and Technology, Kenya (emugalavai@mmust.ac.ke)*

[3]*Department of Disaster Management and Sustainable Development, Masinde Muliro University of Science and Technology, Kenya(schina@mmust.ac.ke)*

**Corresponding author: otwori92@gmail.com*

https://doi.org/10.62049/jkncu.v5i1.161

Abstract

Climate Smart Agriculture (CSA) practices are essential for delivering production inputs, information, germplasm, finance, markets and other resources observed by smallholder farmers. This study aimed to utilize CSA practices to address agricultural production obstacles and enhance food security in Nyamira County. The overall objective was to determine the influence of climate-smart agriculture practices on food security among small-scale farmers in Nyamira County, Kenya. The study adopted a descriptive survey research design, with a sample size of 384 households selected through a multistage sampling approach. Data collection methods included questionnaires, Focus Group Discussions (FGDs), observation checklists, and structured interview schedules. Secondary data was gathered from various sources such as the internet, journals, publications, and document analyses. Quantitative data was analyzed using the Statistical Package for Social Scientists version 25, while qualitative data was summarized through narrative analysis. The findings revealed that mixed cropping at 20.50% (230), crop rotation at 15.15% (170), organic farming at 10.52% (118), and cover cropping at 7.93% (89) all had a significant influence on the food security of the small-scale farmers ($p<0.05$). Conversely, agroforestry at 14.53% (163), drought-resistant crops at 7.49% (84), water harvesting at 13.10% (147), and integrated soil fertility management at 7.31% (82) did not exhibit a significant influence (p-value > 0.05). The logistic regression model showed a statistically significant $\chi2 = 20.267$, $p < 0.05$, between CSA practices and food security. The study recommends that the Nyamira County agriculture department, in conjunction with the national government and non-governmental organizations, promote the upscaling of mixed cropping, crop rotation, organic farming, and cover cropping among smallholder farmers as key CSA practices to enhance household food security in the area.

Keywords: Climate-Smart Agriculture, Food Security, Smallholder Farmers

Introduction

Climate Smart Agriculture (CSA) practices enhance the delivery of production inputs, information, germplasm, finance, markets and other resources observed by smallholder farmers (Makate, 2019). Additionally, it aims to increase and optimize the combination of yields/ productivity and adaptation to climate conditions regarding the sound and efficient management of natural resources, besides supporting climate change interventions (Lipper & Zilverman, 2018). The strategy makes use of tried-and-true technologies as well as other cutting-edge techniques like agroforestry, crop rotation, conservation agriculture, water harvesting, efficient use, cover cropping, intercropping with legumes, irrigation and integrated soil fertility management (ISFM) (Mutengwa *et al*., 2023). Climate change adaptation is achievable through cultivating varieties and breeds that can better withstand these stresses or through the farmer's ability to access timely weather information (Reddy, 2015). CSA practices are essential for achieving the Sustainable Development Goals (SDGs) of the United Nations (UN) in low- and middle-income countries, which include eradicating hunger and combating climate change (FAO, 2018; IPCC, 2018). The Climate-smart agricultural (CSA) practices have triple bottom-line opportunities to reverse this trend since they enhance produce productivity and income, reduce greenhouse gas emissions, and increase household food security (Wekesa *et al.*, 2018).

As Nyasimi *et al*., (2017) opined, east African farmers are called upon to update themselves and develop skills in understanding CSA practices, technologies and institutional innovations that could enhance their adaptation to climate change and manage the variability experienced. According to GoK (2014), at least 55 percent of male-headed households, 59 percent of female-headed households and 55 percent of youth-headed households do not have adequate food to sustain them for the year.

Agriculture is a primary income source and a vital economic contributor for most sub-Saharan countries. In Kenya, agriculture accounts for 70% of rural informal employment and contributes to 65% of the nation's exports (Recha, 2018). Most of the smallholder farmers in the country rely on agriculture as the primary source of their income (Ochieng *et al*., 2017). Sadly, this region has been affected and faced detrimental impacts of climate change, which exposed people to heightened food insecurity and reduced agricultural productivity. The ongoing Russia-Ukraine war has had significant ripple effects on global food security, including in Kenya. This conflict has disrupted critical supply chains, especially for key agricultural imports such as wheat and fertilizer, vital for Kenyan agriculture. Kenya imports around 85% of its wheat, with a substantial portion coming from the Black Sea region, including Russia and Ukraine. The war has led to severe wheat shortages, causing prices to spike and impacting the affordability of basic foodstuffs like bread (UNDP, 2022: Lena, 2022).

The disruption in wheat and fertilizer supplies has exacerbated food insecurity, especially for smallholder farmers in Kenya, who are already struggling with the dual challenges of climate change and high input costs. The increased cost of fertilizers has made it harder for farmers to maintain soil fertility, while rising wheat prices have led to inflation in food prices, further straining household food security (Lena, 2022).

Moreover, the war's economic consequences have been compounded by inflation and exchange rate volatility, further undermining Kenya's efforts to ensure food availability and accessibility (UNDP, 2022). This situation underscores the urgency of diversifying Kenya's agricultural inputs and ensuring that smallholder farmers are supported in adopting more resilient practices to mitigate the impacts of such global disruptions.

According to the World Food Summit in 1996, "food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life." In recent years, several significant factors have impeded progress toward eradicating world hunger and malnutrition by 2030 (FAO *et al.*, 2021). The report emphasizes the necessity of a more comprehensive approach to addressing global food security and nutrition. The report provides a substantial evidence-based understanding of the primary drivers behind recent food security and nutrition changes by analyzing data from the past four editions. Food insecurity is on the rise due to several worsening problems. These include armed conflicts, increasingly volatile weather patterns, and economic downturns. All of these factors are made even more severe by existing poverty and vast income inequality. Millions of people worldwide can't afford healthy foods, contributing to hunger and various nutritional deficiencies (FAO *et al.*, 2021).

Kenya's national per capita daily energy consumption falls below the recommended levels (Stoppok *et al.*, 2018). Even in years of good food production, chronic undernutrition, represented by stunting, affects 30% of children. This condition indicates long-term insufficient dietary intake of food, including macronutrients such as carbohydrates, proteins, and fats, as well as micronutrients like vitamins and minerals. This situation contributes to insufficient food distribution, limited access to high-quality foods, inadequate knowledge about feeding and caregiving for young children, and repeated infections (GoK, 2009; GoK, 2011). The 2022 Kenya poverty report revealed that a significant portion of the Kenyan population faces food insecurity. The report indicated that the overall poverty headcount rate was 39.8 percent, implying that over 20 million individuals could not meet the overall poverty line threshold. Estimated at an individual level, the national food poverty headcount rate in 2022 was 31.7 percent, translating to over 16 million people being unable to meet the food poverty line threshold. These figures underscore the pressing need to address Kenya's food security and nutrition challenges and develop strategies to help alleviate these issues and improve the population's overall well-being (KNBS, 2024).

Agriculture is vital to Nyamira County's economy, contributing to approximately 90% of its Gross Domestic Product (GDP). Within the agricultural sector, crop production accounts for 50% of the agricultural GDP and employs a substantial portion of the local labour force. This sector significantly influences the socio-economic development of the County by providing households with food, income, and nutritional security (GoK, 2016). The agricultural sector in Nyamira County can produce enough crops and animal products to meet domestic and industrial market demands and generate surplus products for export. Small-scale farmers typically own land parcels of around 0.7 hectares, while large-scale farmers have larger holdings of approximately 4 hectares. These farm holdings are concentrated in high-potential areas (GoK, 2021).

It is worth noting that the fragmentation of land into smaller holdings has led to a significant increase in the number of farm holdings in the County. As a result, the agricultural sector has the potential to create a substantial number of jobs, reduce poverty, and alleviate pressure on capture fisheries. The success of this industry is central to Nyamira County's economic performance and overall development (GoK, 2015). Therefore, this study sought to assess how adopting climate-smart agriculture has improved food security in Nyamira County, Kenya.

Research Methodology

Study Area

Nyamira County is among the forty-seven counties in Kenya. From the North, it borders Homabay County, while to its West is Kisii County, Bomet County to the Southeast and Kericho County to the east. Nyamira County covers an area of 899.4 square kilometres and is located between latitudes 00° 30' and 00° 45' South and longitudes 34° 45' and 35° 00' East (Figure 3.1). The County does not share borders with any foreign nation and lacks significant water bodies within its territory (GoK, 2018).

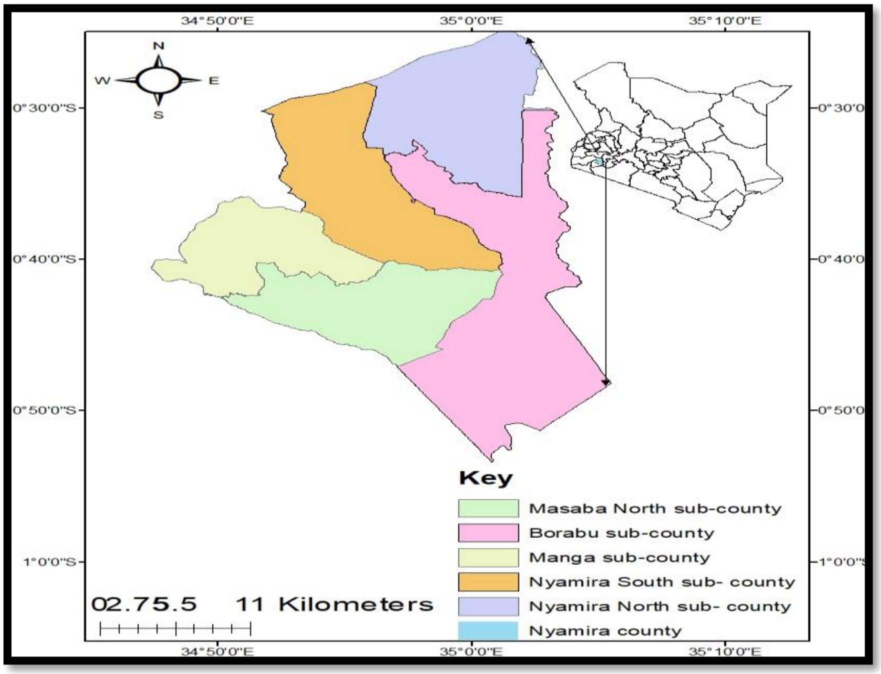


Figure 1: Map of the Study Area Showing the Geographical Location of Sub-Counties of Nyamira County, Kenya

Source: Authors (2023)

Research Design

The study utilized a descriptive survey research design. According to Kothari (2004), a descriptive research design involves a systematic empirical investigation in which the researcher lacks direct control over independent variables because they have already occurred or are inherently unalterable. Furthermore, as Walingo and Ngaira (2008) suggested, descriptive research helps determine the frequency with which something happens or is related to something else.

Sampling Strategy

Sampling involves selecting a representative subset of a larger target population to investigate specific characteristics of the entire group. This article calculated the household sample size using the Krejcie and Morgan formula (Krejcie & Morgan, 1970), resulting in a sample of 384 households.

A multistage random sampling approach was employed, guided by the 2019 census of enumeration areas within the five sub-counties in Nyamira County. The sample distribution among wards is presented in Table 1.

Table 1: Distribution of respondents among the selected wards in Nyamira County, Kenya

Sub-County	**Wards Selected**	**No. of Households**	**Proportionate Sample Size (Nh= Nh/N*N)**
Nyamira south	Nyamaiya	14,114	120
	Bogichora	4,463	38
Nyamira North	Bokeira	5,464	46
	Bomwagamo	4,127	35
Borabu	Nyansiongo	5,972	51
Manga	Kemera	2,336	20
Masaba North	Gachuba	8,828	75
Total		45,304	384

Source: Authors (2023); GoK, (2020)

The sampling process was conducted in three stages. First, all five sub-counties in Nyamira County were included through census sampling to account for the region's diverse climatic and agroecological zones (AEZs). Second, 30% of the wards in each sub-county were randomly selected, adhering to Mugenda and Mugenda's (2003) guideline that a 10-30% sample size is suitable for qualitative research. Selected wards included Nyamaiya and Bogichora in Nyamira South, Bokeira and Bomwagamo in Nyamira North, Nyansiongo in Borabu, Kemera in Manga, and Gachuba in Masaba North.

Finally, households within these wards were systematically selected. Proportionate sampling ensured equitable representation across words, as shown in Table 2. This approach provided a comprehensive and balanced sample of Nyamira County's population dynamics.

Food Security Metrics

Household Dietary Diversity Score (Hdds)

The HDDS is a simple way to assess household diets by asking people what they ate on the last day. This short recall period makes it easier for people to remember accurately and reduces the risk of forgetting. Similar to other dietary diversity studies, the HDDS focuses on the variety of food groups consumed within a day (Huluka *et al*., 2019).

Many studies have shown that HDDS is crucial for understanding food security (Mango *et al*., 2014; Sibhatu & Qaim, 2017; Wekesa *et al*., 2018). Goshu *et al*., (2013) found a strong link between HDDS and essential factors like calorie and protein intake, making it a valuable indirect measure of food security. In simpler terms, the variety of foods a household eats (as shown by HDDS) reflects their diet and ability to afford different types of food (Mango *et al*., 2014). The HDDS considers twelve food groups: (A) Cereals, (B) Root and tubers, (C) Vegetables, (D) Fruits, (E) Meat and poultry (F) Eggs, (G) Fish and seafood, (H) Pulses, legumes, and nuts, (I) Milk and milk products, (J) Oil and fats, (K) Sugar and honey, and (L) Spices, Condiments and Beverages. Each food group counts as one point if the household consumed it in the past 24 hours. The total score can range from zero (if no groups were consumed) to twelve (if all groups were consumed). Therefore, the HDDS is equal to the total number of food groups consumed by the household, and it is given by:

$$HDDS = Sum (A + B + C + D + E + F + G + H + I + J + K + L)$$

FAO (2022) created a system to classify households as food secure or insecure using households' HDDS scores. The average score is then used to determine whether a household has enough variety in its diet (FAO, 2022).

Household Food Consumption Score (HFCS)

The HFCS builds on the HDDS by considering how often a household eats certain foods (Mango *et al*., 2018). It considers what people ate the preceding week and categorizes it into eight food groups. Instead of counting the number of different food groups (like the HDDS), the HFCS assigns weights based on importance, with more nutritious groups like vegetables getting a higher weight. A final score is calculated by adding up these weighted scores. The overall HFCS score can then classify households into different consumption categories: poor, borderline, or acceptable (Mango *et al*., 2018). Therefore, a higher HFCS indicates a more diverse and nutritious diet.

Binary Logistic Model Specifications

The Binary logistic model was used to examine the influence of CSA practices on household food security. The study established the households' food security based on the HDDS for the 12 food groups that were scored. The households that had consumed each food group scored 1, while those who did not consume scored 0 (Table 2). Therefore, the maximum score was 12 for the households that consumed each food group. Several studies (Abegunde *et al*., 2022; Omotayo *et al*., 2022; Omotoso & Omotayo, 2024) highlight the importance of dietary diversity (DD) in assessing food security. These studies established a scoring system for DD: scores of 3 indicate low diversity, scores of between 4-6 represent medium diversity, and a score of 7 signifies high dietary diversity.

Table 2: Dietary Diversity food groups estimation

S/no	**Food Group**	**Examples**	**Yes=1 No=0**
1	Cereals	corn/maize, rice, wheat, sorghum, millet or any other grains or foods made from these (e.g. bread, noodles, porridge or other grain products) + insert local foods, e.g. ugali, porridge or past	
2	White Roots and Tubers	white potatoes, white yam, white Cassava, or other foods made from roots	
3	Vegetables	pumpkin, carrot, squash, or sweet potato that are orange inside + other locally available vitamin A-rich vegetables (e.g. red sweet pepper)	
4	Fruits	ripe mango, cantaloupe, apricot (fresh or dried), ripe papaya, dried peach, and 100% fruit juice made from these + other locally available vitamin A-rich fruits	
5	Meat, poultry	beef, pork, lamb, goat, rabbit, chicken, duck, other birds, insects	
6	Eggs	eggs from chicken, duck, guinea fowl or any other egg	

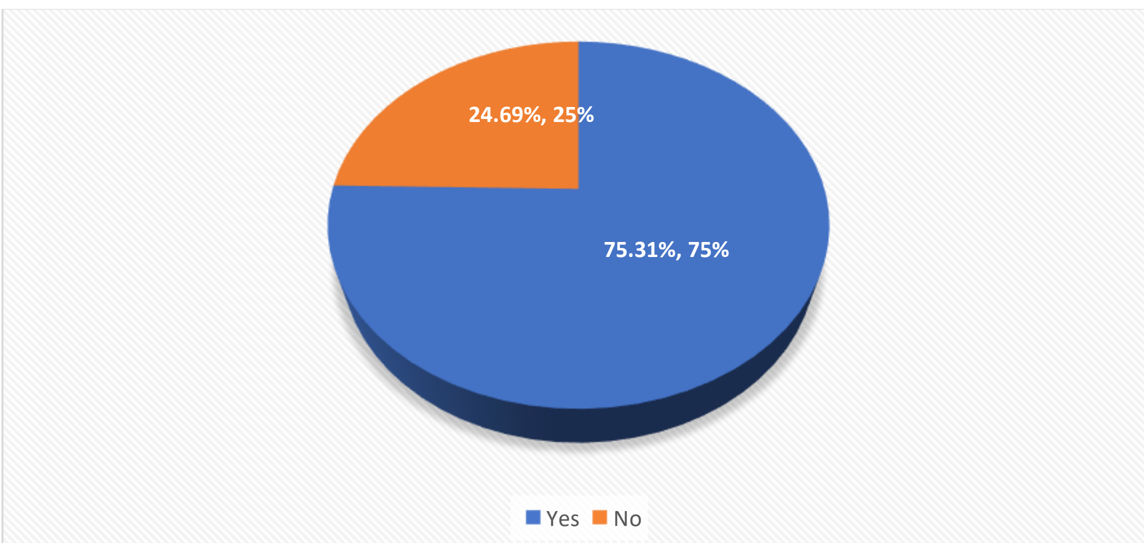
7	Fish And Seafood	fresh or dried fish or shellfish	
8	Pulses, Legumes, Nuts and Seeds	dried beans, dried peas, lentils, nuts, seeds or foods made from these (e.g. hummus, peanut butter)	
9	Milk And Milk Products	milk, cheese, yoghurt or other milk products	
10	Oils And Fats	oil, fats, or butter added to food or used for cooking	
11	Sugar/honey	sugar, honey, sweetened soda or sweetened juice drinks, sugary foods such as chocolates, candies, cookies and cakes	
12	Spices, Condiments, Beverages	spices (black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic beverages	

Source: Swindale & Bilinsky (2006)

Findings and Discussions

Access to Arable Land

The respondents were asked whether they have access to agricultural land (arable land for cultivation). The findings are summarized in Figure 6.1. From the findings, 75.31 % (289) of the respondents had access to arable land for cultivation, while 24.69 % (95) had no access to land for cultivation. These results underscore the critical role of land accessibility in shaping agricultural practices and livelihoods. The high percentage of respondents with access to arable land suggests a potential opportunity for agricultural productivity, while the notable minority without access highlights underlying disparities that could hinder equitable agricultural development.



n-384

Figure 2: Access to arable land by small-scale farmers in Nyamira County, Kenya

Source: Authors (2023)

The farmer's access to arable land is crucial in determining their capacity to embrace various CSA practices. This is because practices such as cropping, nutrient management, and soil and water management inherently rely on the availability of land for effective adoption. Households without adequate access to arable land will be limited on the intensity and diversity of the CSA practices they can adopt. Musafiri *et al.*, (2022) posit that the presence of arable land positively impacts the adoption of CSA. The study's results indicate that smallholder farmers are more likely to adopt multiple CSA practices as the size of their arable land increases.

Crops Grown in Nyamira County, Kenya

The study established the various crops that the respondents grow on their farms. The findings are shown in Table 4. Maize and beans were the main crops grown at 29.67% (178) and beans at 21.67% (130). Other crops that were also grown included vegetables at 18.33% (110), sweet potatoes at 11.67% (70), cassava at 2.33% (14), millet at 2.00% (12), and sorghum at 0.33% (2), respectively. These findings suggest a strong inclination toward staple crops like maize and beans, with limited cultivation of alternative cereals, which may indicate potential underutilization of climate-resilient crops like millet and sorghum.

Table 3: Crops grown by small-scale farmers in Nyamira County, Kenya

Crops	Frequency	Percentage
Maize	178	29.67
Beans	130	21.67
Vegetables	110	18.33
Others	84	14.00
Sweet potatoes	70	11.67
Cassava	14	2.33
Millet	12	2.00
Sorghum	2	0.33
Total		100

*Respondents selected multiple choices; N=384
Source: Authors (2023)

The other 14.00% (84) listed other crops, such as bananas and sugarcane. According to GoK (2023), maize is a primary staple crop in Nyamira, cultivated predominantly on a small scale across four Sub Counties: Manga, Nyamira North, Nyamira South, and Masaba North. The typical farm sizes dedicated to maize range from 0.25 hectares to 0.75 hectares, except in Borabu Sub County, where production occurs on larger farms spanning from 4 hectares to 20 hectares. Like other food crops, maize undergoes two growing seasons annually, with the main season occurring from February to August and the shorter rainy season from September to December. The overall land area dedicated to maize cultivation has shown relatively stable trends (GoK, 2023). The report highlights the impact of climate change on maize production in Nyamira County.

Beans represent another significant food crop that serves as a primary source of plant protein. They are primarily intercropped with maize, although some farmers opt to cultivate climbing beans independently during the short rains season. The predominant bean varieties in Nyamira County include Mwitamania, Rose Coco, Red Haricot, and Climbing Beans (particularly during the short rainy season. While the acreage dedicated to beans is slightly less than that of maize, approximately 70% of farmers incorporate beans as an intercrop with maize. Local vegetables form an important part of the economy of Nyamira County. The

County is known for producing Black nightshade and spider flowers (*Chinsaga*), which attract much demand from the local market and the major urban centres in Kenya (GoK, 2023).

According to GoK (2023), finger millet, historically a significant crop, especially among the older generation, experienced a neglect period where it received little attention. However, it is gradually gaining popularity with shifting dietary preferences and nutrition awareness. It has grown in all five sub-counties and is doing well due to favourable conditions. It is grown during the Long Rains (LR) and Short Rains (SR) seasons. Additionally, sweet potato cultivation has become increasingly popular among farmers in Nyamira County, particularly in the lower regions such as Bomwagamo, Bokeria, Magwagwa, Bogichora, and Nyamaiya wards. Recognized as a vital food security crop, sweet potatoes thrive in areas with limited rainfall.

Another cultivated crop was Cassava, which is crucial as a food security crop, yet it has not gained widespread popularity among most farmers. This is primarily due to insufficient knowledge regarding its harvesting and utilization as food, often stemming from concerns about occasional cassava poisoning (Gok, 2023). Banana cultivation has been a longstanding practice in Nyamira, with the local green banana variety being the primary choice for farmers, commonly found in nearly every homestead. However, once popular, the sweet variety known as *Kisukari* has almost vanished due to its vulnerability to Panama disease. Despite this setback, banana production has steadily increased in the area dedicated to banana cultivation and the yields per unit area.

Quantity of the Crops Produced from the Farm in Nyamira County, Kenya

The study established the quantity of crops that the small-scale farmers produce during the short and long rains. The findings are presented in Table 4. The findings showed that the mean production of 90 kg bags for maize was 46.45 bags, beans were 20.58 bags, and vegetables were 12.17 bags. Other crops produced during the short rains were Cassava at 1.29 bags, sweet potatoes at 5.87 bags, millet at 0.38 bags, and sorghum at 0.42 bags.

Table 4: Crops produced by small-scale farmers in Nyamira County during the short rains

Crops Grown	**Mean (90kg bags)**
Maize	46.45
Beans	20.58
Cassava	1.29
Sweet potatoes	5.87
Vegetables	12.17
Millet	0.38
Sorghum	0.42

Source: Authors (2023)

The survey participants also provided information on the quantity of 90kg bags produced in the long rainy season (Table 5). The results reveal that maize production was 86.65 bags, followed by beans at 34.26 bags, vegetables at 17.94 bags, sweet potatoes at 8.26 bags, Cassava at 0.86 bags, millet at 0.63 bags, and sorghum at 0.62 bags.

Table 5: Crops produced by small-scale farmers in Nyamira County during the long rains season

Crop grown	Mean (90kg bags)
Maize	86.65
Beans	34.26
Cassava	0.86
Sweet potatoes	8.26
Vegetables	17.94
Millet	0.63
Sorghum	0.62

Source: Authors (2023)

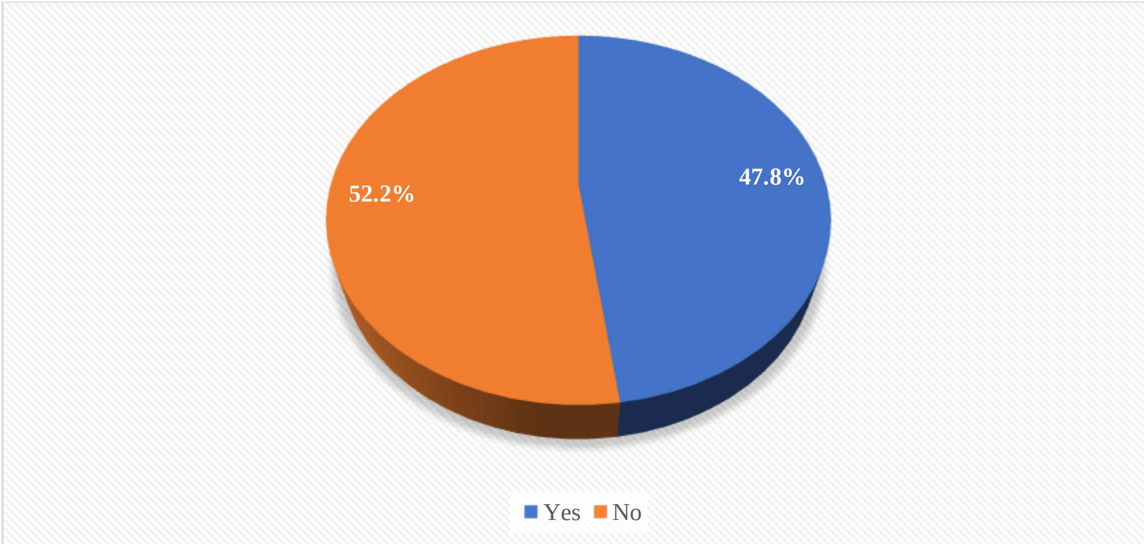
The disparity in production volumes among the crops underscores the need for deliberate strategies to promote diversification in agricultural systems. While maize remains critical to food security, the underrepresentation of resilient crops like cassava, millet, and sorghum raises concerns about the long-term sustainability of agricultural practices in the study area. Enhancing awareness of the nutritional and economic benefits of these crops could encourage their cultivation.

Moreover, the moderate production of vegetables suggests a potential shift towards integrating nutritional goals into farming systems. This trend could be amplified through capacity-building programs that support farmers in adopting best practices for high-value crops.

Access to Farming Technologies and Practices for Increased Food Production

The respondents were asked whether they had access to farming technologies and practices to improve their food production. The findings are summarized in Figure 3. The results show that 52.2% (200) of the respondents had no access to farming technologies and practices; however, 47.8% (184) had access. These results highlight a concerning gap in the adoption and availability of modern farming technologies and practices essential for enhancing agricultural productivity and ensuring food security. The near parity in responses underscores the progress in extending access to some farmers and the pressing need to address barriers preventing others from benefiting.

The lack of access among over half of the respondents suggests systemic challenges, such as inadequate infrastructure, limited financial resources, or insufficient extension services. This disparity limits the capacity for improved agricultural output and exacerbates vulnerabilities among farmers already facing climatic and economic pressures. Addressing these barriers is pivotal for fostering inclusive and sustainable agricultural development in the study area.



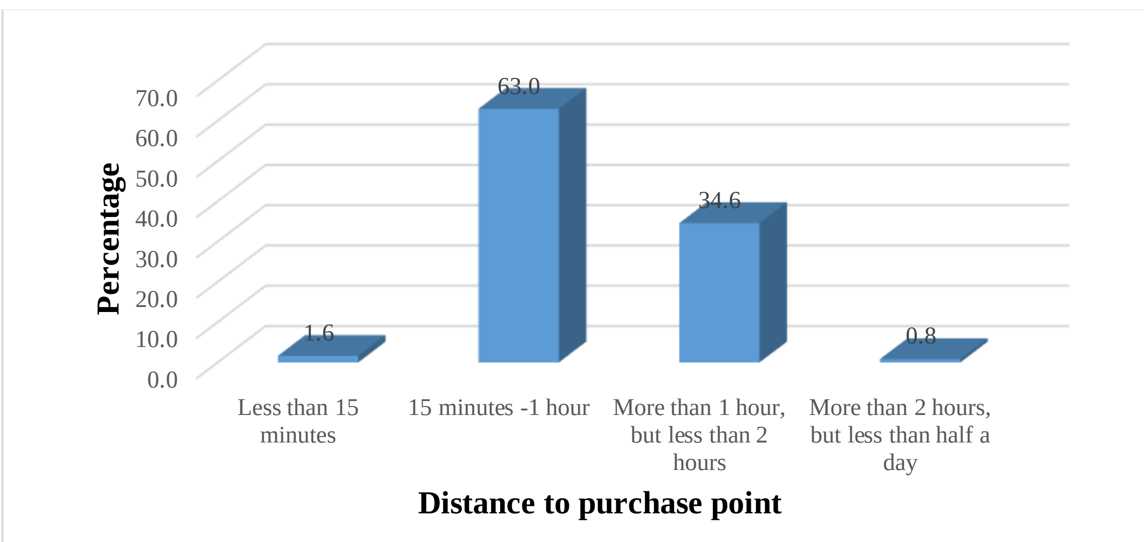
N=384

Figure 3: Access to Farming Technologies and Practices by Small-Scale Farmers in Nyamira County, Kenya

Source: Authors (2023)

Distance of Food Purchase Point from the House

The respondents provided information on the distance and time from the house to reach the food purchase point. The findings are shown in Figure 4. The findings show that 63.0% (242) of them used approximately 15-60 minutes to reach the food purchase point, while 34.6% (133) spent more than one hour but less than two hours to get the purchase point. Only 1.6% (6) spent less than 15 minutes to the end, and 0.8% (3) spent more than two hours to the purchase point.



N=384

Figure 4: Time Taken by Small-Scale Farmers to the Food Purchase Point in Nyamira County, Kenya

Source: Authors (2023)

These findings reveal a dual reality whereby the majority experience reasonable access, a significant minority faces prolonged travel times that may undermine food security. Extended travel times can increase household vulnerability by reducing the frequency of food purchases, limiting diet diversity, and escalating transportation costs. These results emphasize the importance of addressing geographical inequities in food accessibility. Strategies such as decentralized food markets, improved transportation networks, and community-based food distribution systems could enhance accessibility, ensuring that all households, regardless of location, can achieve consistent and timely access to food.

Challenges to Physical Access to the Purchase Point in Nyamira County, Kenya

The study examined the constraints to physical access to food purchase points, shedding light on critical barriers impacting food security in the area. As illustrated in Table 6, the most significant challenge cited by respondents was the lack of roads or the presence of bad roads, reported by 41.80% (242) respondents. This finding underscores the vital role of infrastructure in enabling efficient food access, as poor road conditions can severely impede mobility, escalate transportation costs, and limit timely access to markets. 24.70% (143) of respondents identified long distances to food purchase points as the second most common constraint. This highlights the geographical isolation of certain communities, which can exacerbate food insecurity by reducing the frequency and affordability of food procurement.

Other notable challenges included insecurity (14.51%, 84) respondents and adverse weather conditions like floods (12.78%, 74) respondents. These factors point to the complex interplay between physical, environmental, and social barriers, where unpredictable weather and safety concerns hinder reliable food market access. Additionally, 5.87% (34) of respondents reported market inoperability during certain months, reflecting the region's seasonal limitations of food systems.

These findings emphasize the multifaceted nature of access constraints and their implications for food security. Addressing these barriers requires integrated solutions, such as investments in road infrastructure, improved security measures, climate-resilient market systems, and policies to ensure consistent market operations. Without these interventions, the structural challenges to physical food access may continue to undermine efforts to achieve food security for all households in the area.

Table 6: Summary of Challenges to Physical Access by Small-Scale Farmers to Food Purchase Point

Challenge	Frequency	Percentage
Lack of roads/bad road conditions	242	41.80
Long distance	143	24.70
Insecurity	84	14.51
Weather conditions (floods)	74	12.78
The market has not been operational for some months	34	5.87
Others	2	0.35
Total		100.00

*Respondents selected multiple choices; N=384
Source: Authors (2023)

Household Food Security

The study established the household's food security based on the HDDS for the 12 food groups that were scored. Scores of 3 indicate low diversity, scores of between 4-6 represent medium diversity, and a score of 7 and above signifies high dietary diversity (Abegunde *et al.*, 2022; Omotayo *et al.*, 2022; Omotoso & Omotayo, 2024). Therefore, this study adopted this type of classification of the households into three categories, as shown in Table 7.

Table 7: HDDS categories classification of small-scale farmers in Nyamira County, Kenya

HDDS categories	Frequency	Percentage
Low dietary diversity	36	9.46
Medium dietary	135	35.14
High dietary	213	55.41
Total	384	100
The mean score of HDDS	6.6	S.D 2.20

Source: Authors (2023)

Once the households were classified into the three dietary diversity categories as shown in Table 9, they were further classified into two categories: food secure or food insecure, with the mean score of HDDS (mean= 6.6, S.D 2.2) as the reference point. Those with a score less than the mean were classified as food insecure, while those with a more than the mean were classified as food secure (Table 8).

Table 8: Classification of food security status of Small-scale Farmers in Nyamira County, Kenya

Food security status	Frequency	Percentage
Food secure	213	55.41
Food insecure	171	44.6
Total	384	100.00

Source: Authors (2023)

A binary logistic model was conducted on the CSA practices the respondents had adopted and the household's food security. The model variables used in the model are shown in Table 9.

Table 9: Variable description used in the model

Variable	Description	Measurement
Food security	Food security status	Food secure, 0- food insecure
CSA1	Mixed Cropping	1 Yes, 0- no (Dummy)
CSA2	Agroforestry	1 Yes, 0- no (Dummy)
CSA3	Crop rotation	1 Yes, 0- no (Dummy)
CSA4	Cover cropping	1 Yes, 0- no (Dummy)
CSA5	Organic farming	1 Yes, 0- no (Dummy)
CSA6	Drought resistant crops	1 Yes, 0- no (Dummy)
CSA7	Water harvesting	1 Yes, 0- no (Dummy)
CSA8	Integrated soil fertility management	1 Yes, 0- no (Dummy)
CSA9	Others	1 Yes, 0- no (Dummy)

Source: Authors (2023)

The study used the described variables in the model to determine the influence of CSA practices on household food security in Nyamira County, Kenya. The results from the model are shown in Table 10.

Table 10: Logit regression model analysis

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1a	Mixed cropping	.045	.294	.024	1	.048	1.047
	Agroforestry	-.198	.275	.519	1	.471	.820
	Crop rotation	.518	.257	4.053	1	.044	1.678
	Cover cropping	.331	.304	1.184	1	.000	1.393
	Organic farming	-.588	.348	2.858	1	.001	.556
	Drought resistant crops	-.353	.386	.833	1	.361	.703
	Water harvesting	-.406	.300	1.834	1	.176	.666
	Integrated soil fertility management (ISFM)	.241	.312	.598	1	.439	1.272
	Others	-.101	.403	.062	1	.803	.904
	Constant	.342	.301	1.292	1	.256	1.408
a. Variable(s) entered on step 1: Mixed cropping, Agroforestry, Crop rotation, Cover cropping, Organic farming, Drought resistant crops, water harvesting, integrated soil fertility management, others.							

Source: Authors (2023)

A logistic regression was performed to ascertain the influence of the different CSA practices on household food security. The logistic regression model was statistically significant, $\chi2 = 20.267$, $p < 0.05$. The model explained 71.0% (Nagelkerke R^2) of the variance in food security and correctly classified 61.4% of cases as either food secure or insecure. From the findings in Table 11, the analysis highlights critical practices that influence agricultural productivity and household food security. Among the practices, mixed cropping, crop rotation, and cover cropping emerged as the most effective strategies. Mixed cropping demonstrated a positive and statistically significant effect on food security, with a slight increase in the odds of enhancing agricultural outcomes. Similarly, crop rotation had a strong and significant positive impact, substantially improving the odds of food security by diversifying crop production and improving soil health. Cover cropping also showed a positive and significant association, contributing to improved agricultural resilience and productivity.

Conversely, practices such as organic farming and drought-resistant crops showed mixed results. Organic farming displayed a statistically significant negative impact, potentially reflecting challenges in its implementation or the costs associated with transitioning to organic methods. Although conceptually beneficial, drought-resistant crops and water harvesting did not show significant effects in this context, possibly due to limited adoption or inefficiencies in application.

Other practices, including agroforestry and integrated soil fertility management (ISFM), showed no significant influence on food security in this study. These findings suggest that while these methods may offer long-term benefits, their immediate impact on food security was not evident in the sampled population.

In conclusion, the findings underscore the importance of promoting practices like mixed cropping, crop rotation, and cover cropping as they significantly contribute to food security. Efforts should also address the barriers to adopting other CSA practices to fully realize their potential in enhancing agricultural resilience and food security.

Impact of CSA on Food Security

The study established how the adoption of CSA has influenced food security in the households in Nyamira County, Kenya. Figure 5 shows the findings. Most respondents, 76.5% (294), stated that the CSA practices had influenced their households' food security. In comparison, 23.5% (90) said it had not influenced food security in their households.

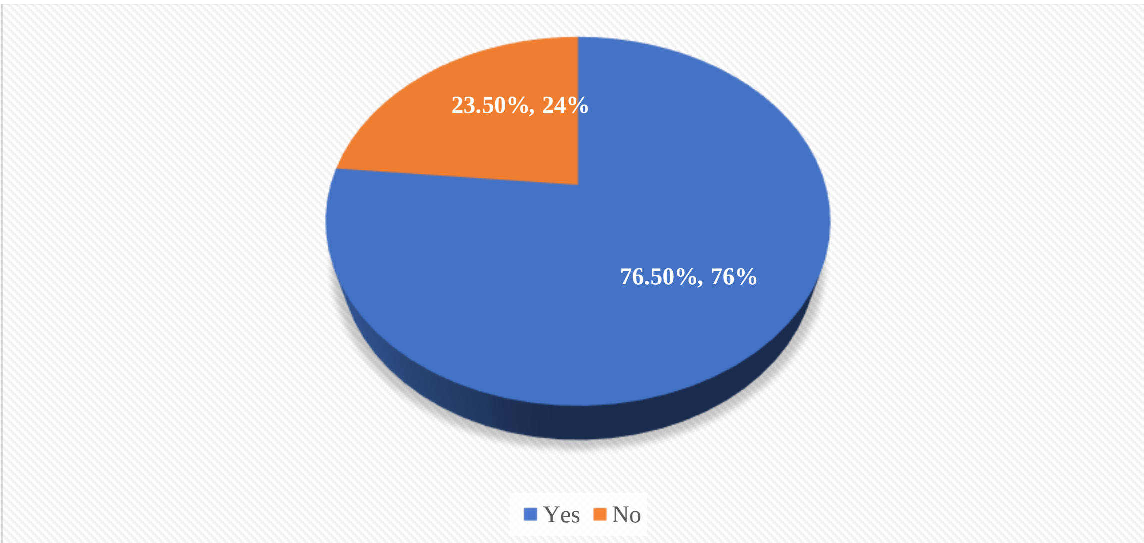


Figure 5: Impact of CSA on food security in Nyamira County, Kenya

Source: Authors (2023)

Research conducted by Songok *et al*., (2011) revealed that the direct impacts of climate change on food security prompt households to employ a combination of indigenous and modern practices to adapt to climate change and manage the associated risks of food insecurity. A study by Omotoso and Omotayo (2024) also explored how implementing climate-smart agricultural practices in Nigeria improves dietary diversity and food security. The research found that households practicing climate-smart farming showed greater diversity in their food consumption and experienced enhanced food security.

The respondents were also asked how the CSA has influenced food security in the study area. The findings are summarized in Table 11. The findings revealed that 69.74% (268) of the respondents agreed that CSA has improved food security among households, and 7.89% (30) stated that it has improved crop productivity. Others noted that it has led to proper utilization of the available resources and reduced expenditure on purchasing food items. This study's findings agree with a study by Zheng *et al.* (2024), which found that switching to climate-smart agriculture (CSA) practices often leads to bigger and more profitable farm harvests. This means farms get more crops, make more money, and use resources more effectively. Additionally, CSA practices make farms and the entire food system more adaptable by improving people's diets, reducing the risk of food shortages, and helping farmers cope with unpredictable weather. These practices are also good for the environment because they reduce greenhouse gases and improve soil health.

Table 11: Impact of CSA on food security in Nyamira County, Kenya

Effect	Frequency	Percentage
Improved food security	268	69.74
Improved crop produce	30	7.89
Learned how to utilize available resources	5	1.32
Reduced expenditure on the purchase of food items	81	21.05
Total	384	100

Source: Authors (2023)

Conclusions and Recommendations

Conclusions

In conclusion, this study demonstrates that climate-smart agriculture (CSA) practices, such as mixed cropping, crop rotation, organic farming, and cover cropping, are crucial in enhancing household food security by significantly improving crop productivity. These findings highlight the importance of integrating specific CSA practices into agricultural strategies to address food insecurity. However, the study also reveals that not all CSA practices have the same level of impact. Agroforestry, using drought-resistant crops, water harvesting, and integrated soil fertility management, while valuable for other environmental and resilience-building purposes, did not exhibit a statistically significant effect on household food security in the study area.

The logistic regression model confirmed the overall importance of CSA practices in influencing food security, with a statistically significant result ($\chi^2 = 20.267$, $p < 0.05$). The model explained 71% of the variance in household food security and correctly classified 61.4% of households as either food secure or insecure, underscoring the relevance of the selected practices. In the future, agricultural interventions should prioritize CSA techniques that have been proven effective in improving food security. At the same time, further research and localized assessments could help uncover the underlying reasons for the limited impact of other practices. This approach can better inform policymakers and stakeholders in promoting sustainable agricultural practices aligning with food security and climate resilience objectives.

Recommendations

The study recommends that agricultural policymakers and development agencies prioritize promoting and scaling climate-smart agriculture (CSA) practices that have positively impacted household food security, specifically mixed cropping, crop rotation, organic farming, and cover cropping. These practices should be integrated into agricultural development programs and extension services to improve food security in vulnerable communities. It is also advisable to conduct further research and pilot projects to understand better the limitations and potential benefits of CSA practices that did not show a statistically significant impact on food security, such as agroforestry, drought-resistant crops, water harvesting, and integrated soil fertility management. Tailoring these practices to specific local conditions may uncover their full potential, allowing for a more comprehensive approach to sustainable agricultural development and resilience building.

References

Abegunde, V. O., Sibanda, M., & Obi, A. (2022). Effect of climate-smart agriculture on household food security in small-scale production systems: A micro-level analysis from South Africa. *Cogent Social Sciences, 8*(1), 1–27. https://doi.org/10.1080/23311886.2022.2086343

Alemu, T., & Mengistu, A. (2019). Impacts of climate change on food security in Ethiopia: Adaptation and mitigation options: A review. *Climate Change-Resilient Agriculture and Agroforestry: Ecosystem Services and Sustainability*, 397–412.

Barnett, J. (2020). Climate change and food security in the Pacific Islands. *Food Security in Small Island States*, 25–38.

FAO, ECA, & AUC. (2021). *Africa-Regional Overview of Food Security and Nutrition 2021: Statistics and trends*. Accra, FAO, 1–73.

FAO. (2018). *The Future of Food and Agriculture*. FAO, 1–180.

FAO. (2022). *Climate-smart agriculture sourcebook*. United Book Prints, 1–570.

GoK. (2009). *Agriculture Sector Development Strategy*.

GoK. (2011). *National Food and Nutrition Security Policy*. Nairobi, 1–60.

GoK. (2014). *Nyamira County*. Ministry of Agriculture, Livestock and Fisheries. Nairobi: Government of Kenya, 1–98.

GoK. (2015). *Nyamira County Annual Development Plan 2014/2015*. 1–112.

GoK. (2016). *Kenya National Adaptation Plan: 2015-2030*. Government of Kenya, July 2016, 1–68.

GoK. (2018). *Nyamira County Integrated Development Plan (2018–2023)*. 1–728.

GoK. (2020). *Kenya National Bureau of Statistics: Economic Survey*. Nairobi, Kenya: Government Printer.

GoK. (2021). *Climate Risk Profile for Nyamira County*. Kenya County Climate Risk Profile Series. The Ministry of Agriculture, Fisheries and Co-operatives (MoALFC)), Nairobi, Kenya, 1–40.

GoK. (2023). *Nyamira County Integrated Development Plan 2023–2027*. 1–447.

Goshu, D., Kassa, B., & Ketema, M. (2013). Measuring diet quantity and quality dimensions of food security in rural Ethiopia. *Journal of Development and Agricultural Economics, 5*(5), 174–185.

Hasan, M. K., Desiere, S., D'Haese, M., & Kumar, L. (2018). Impact of climate-smart agriculture adoption on the food security of coastal farmers in Bangladesh. *Food Security, 10,* 1073–1088.

Huluka, A. T., & Wondimagegnhu, B. A. (2019). Determinants of household dietary diversity in the Yayo biosphere reserve of Ethiopia: An empirical analysis using sustainable livelihood framework. *Cogent Food & Agriculture*, *5*(1), 1–29. https://doi.org/10.1080/23311932.2019.1690829

IPCC. (2018). *Global warming of 1.5*. Special Report Intergovernmental Panel on Climate Change, 24.

Kabubo-Mariara, J., & Mulwa, R. (2019). Adaptation to climate change and climate variability and its implications for household food security in Kenya. *Food Security, 11*, 1289–1304.

KNBS. (2024). *Poverty Report: Based on the 2022 Kenya Continuous Household Survey*. Nairobi, Kenya.

Kogo, B. K., Kumar, L., & Koech, R. (2021). Climate change and variability in Kenya: A review of impacts on agriculture and food security. *Environment, Development and Sustainability, 23*, 23–43.

Simet, L. (2022). Ukraine/Russia: As War Continues, Africa Food Crisis Looms Provide Aid, Expand Social Protection to Prevent Hunger. Retrieved November 22, 2024, from https://www.hrw.org/news/2022/04/28/ukraine/russia-war-continues-africa-food-crisis-looms

Lipper, L., & Zilberman, D. (2018). A short history of the evolution of the climate-smart agriculture approach and its links to climate change and sustainable agriculture debates. *Climate Smart Agriculture: Building Resilience to Climate Change*, 13–30.

Makate, C. (2019). Effective scaling of climate-smart agriculture innovations in African smallholder agriculture: A review of approaches, policy, and institutional strategy needs. *Environmental Science & Policy, 96*, 37–51.

Mango, N., Zamasiya, B., Makate, C., Nyikahadzoi, K., & Siziba, S. (2014). Factors influencing household food security among smallholder farmers in the Mudzi district of Zimbabwe. *Development Southern Africa, 31*(4), 625–640.

Musafiri, C. M., Kiboi, M., Macharia, J., Ng'etich, O. K., Kosgei, D. K., Mulianga, B., Okoti, M., & Ngetich, F. K. (2022). Adoption of climate-smart agricultural practices among smallholder farmers in Western Kenya: Do socio-economic, institutional, and biophysical factors matter? *Heliyon, 8*(1), 1–8.

Mutengwa, C. S., Mnkeni, P., & Kondwakwenda, A. (2023). Climate-smart agriculture and food security in Southern Africa: A review of smallholder agriculture and food security vulnerability to climate change. *Sustainability, 15*(4), 2882. https://doi.org/10.3390/su15042882

Nyasimi, M., Kimeli, P., Sayula, G., Radeny, M., Kinyangi, J., & Mungai, C. (2017). Adoption and dissemination pathways for climate-smart agriculture technologies and practices for climate-resilient livelihoods in Lushoto, Northeast Tanzania. *Climate, 5*(3), 63.

Ochieng, J., Kirimi, L., & Makau, J. (2017). Adapting to climate variability and change in rural Kenya: Farmer perceptions, strategies, and climate trends. *Natural Resources Forum, 41*(4), 195–208.

Omotayo, A. O., Omotoso, A. B., Daud, S. A., Omotayo, O. P., & Adeniyi, B. A. (2022). Rising food prices and farming households' food insecurity during the COVID-19 pandemic: Policy implications from Southwest Nigeria. *Agriculture, 12*(3), 363.

Omotoso, A. B., & Omotayo, A. O. (2024). Enhancing dietary diversity and food security through the adoption of climate-smart agricultural practices in Nigeria: A micro-level evidence. *Environment, Development and Sustainability*, 1–18.

Recha, C. W. (2018). Local and regional variations in conditions for agriculture and food security in Kenya. *AgriFoSe2030 Report, 7*, 1–26.

Reddy, P. P. (2015). Climate change adaptation. *Climate-resilient agriculture for ensuring food security*, 223–272.

Sibhatu, K. T., & Qaim, M. (2017). Rural food security, subsistence agriculture, and seasonality. *PLOS One*, *12*(10), e0186406, 1–15.

Songok, C. K., Kipkorir, E. C., & Mugalavai, E. M. (2011). Integration of indigenous knowledge systems into climate change adaptation and enhancing food security in Nandi and Keiyo districts, Kenya. *Experiences of Climate Change Adaptation in Africa*, 69–95.

Stoppok, M., Jess, A., Freitag, R., & Alber, E. (2018). Of culture, consumption, and cost: A comparative analysis of household energy consumption in Kenya, Germany, and Spain. *Energy Research & Social Science, 40*, 127–139.

Swindale, A., & Bilinsky, P. (2006). Household dietary diversity score (HDDS) for measurement of household food access: Indicator guide. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development, 1–8.

UNDP. (2022). *The Economic Impact of the War in Ukraine on Kenya's Economy*. (Policy Brief). United Nations Development Programme, Kenya. Retrieved from https://www.undp.org/kenya/publications/economic-impact-war-ukraine-kenyas-economy

Walingo, M. K., & Ngaira, K. W. (2008). *Research methods for social and behavioural sciences*. Kisumu: Lake Publishers and Enterprise.

Wekesa, B. M., Ayuya, O. I., & Lagat, J. K. (2018). Effect of climate-smart agricultural practices on household food security in smallholder

Zheng, H., Ma, W., & He, Q. (2024). Climate-smart agricultural practices for enhanced farm productivity, income, resilience, and greenhouse gas mitigation*: A comprehensive review*. *Mitigation and Adaptation Strategies for Global Change, 29*(4), 1–38.