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Contribution of Climate-Smart Agricultural Practices on Food Availability among Smallholder Farmers in Laikipia County, Kenya

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Abstract— Climate change has negatively impacted on bio-diversity, rural livelihoods, national and global economies. Several smallholder farmers in Laikipia County have adopted a number of Climate Smart Agricultural Practices (CSAPs) as mitigation measures and coping strategies, including water harvesting and use, conservation agriculture, agroforestry, pest and disease control, and crop diversification. This study sought to assess the contribution of climate smart agricultural practices on food availability among smallholder farmers in Laikipia County, Kenya. It was guided by the action theory of adaptation and the correlation research design was used. The accessible population were 74,282 households who were practicing small scale farming in Laikipia County during the 2021/2022 cropping season. A multi-stage sampling technique was used to obtain a representative sample of 384. Questionnaire and Key Informant Interviews (KIIs) were used to collect primary data. Descriptive and inferential statistics (ordered logistic regression) using Statistical Package for Social Scientists (SPSS) program version 28 were used to analyze data. Results showed that food availability significantly improved as a result of climate-smart agriculture [the coefficient for Climate-Smart Agriculture (0.400) was positive and statistically significant at 5% (p-value = 0.000)]. Smallholder farmers who have not implemented CSAPs recommendations should be encouraged to start practicing due to its positive contribution to food availability.

Key Words— Climate-Smart Agricultural Practices, Food Availability, Smallholder Farmers.

1. INTRODUCTION

Climate change has emerged as a critical development issue in the global discourse. Some of the negative impacts of climate change relate to biodiversity, livelihoods, national and global economies (Carlson & Shumba, 2011).

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The changing climate is a challenge for both current and future generations. As part of the decision to adopt the Paris Agreement, the Intergovernmental Panel on Climate Change (IPCC) was invited to produce, in 2018, a Special Report on global warming of 1.5°C above pre- industrial levels and related global greenhouse gas emission pathways.

According to IPCC (2018), it is undeniable that the world is already seeing the consequences of 1°C of global warming through more extreme weather, rising sea levels and diminishing arctic sea ice, among other changes. A number of climate change impacts could however be avoided by limiting global warming to 1.5°C compared to 2°C, or more. Limiting global warming would also give people and ecosystems more room to adapt and remain below relevant risk thresholds.

Climate change threatens the progress in poverty reduction and achievement of the Sustainable Development Goals (SDGs) (Gilbert, 2015). The climate change impacts are likely to accentuate the existing shocks and stresses faced by many communities in developing countries. Economic costs of climate change have been estimated to negatively impact the GDP of any country if no measures are taken either to adapt to or mitigate its effect (Stern, 2006). Aggravated by pollution, over-exploitation of natural resources and environmental degradation, climate change will lead to severe, pervasive and irreversible changes for people, assets, economies and ecosystems around the world (UNDP, 2017). Climate change continues to wreak havoc on smallholder farming and it is apparent that it will continue to do so into the foreseeable future. Climate change can disrupt food availability, reduce access to food, and affect food quality (USDA, 2016). Projected increases in temperatures, changes in precipitation patterns, changes in extreme weather events, and reductions in water availability may all result in reduced agricultural productivity. Increases in the frequency and severity of extreme weather events can also interrupt food delivery. Non-functional food system results into spikes in food prices which consequently result into increased frequency of extreme events in the future. Innovative ways are therefore necessary in preparing farmers to cope with the effects of climate change. The ability of smallholder farmers to anticipate, absorb, accommodate, or recover from the effects of extreme climate event in a timely and efficient manner can be controlled through adaptation of climate smart agricultural practices.

Climate Smart Agricultural Practices (CSAPs) form an important coping strategy in developing countries. There are different types of climate smart agriculture (CSA) practices such as: water harvesting and use, pest and disease control, conservation agriculture, agroforestry, and agricultural diversification. These practices contribute to food security and adaptation to climate change. According to Imran *et al.* (2018), CSA practices offer a practical solution to the problem of declining food production and have major implications for food security. Conceptually, CSA practices are approaches for transforming and reorienting agricultural systems to support food security under the new realities of climate change (Lipper *et al.*, 2014).

Reports such as Climate Change, Agriculture and Food Security, CCAFS (2020) and Sapkota *et al.* (2014), show that Climate Smart Agricultural Practices are effective ways through which smallholder farmers adapt to climate change. The concept of climate smart agriculture has been advanced in Africa. Schmidhuber and Tubiello (2007) argue that extreme weather events such as droughts have increased in frequency and intensity in Africa. In Southern Africa, increasing crop productivity through intensification options from CSA practices is a priority for the region. The sub-region also has some of the least diversified cropping systems and critical challenge in addressing chronic food and nutrient insecurity and land degradation in the face of climate change reality (Mapfumo *et al.*, 2014).

In East Africa, CSA practices have been widely promoted by key development agencies. Some of these practices include water harvesting and use, diversification and stronger emphasis on combined soil and water management to enhance soil fertility, reduce degradation and increase capacity to deliver water to root systems during critical growing periods (Nicol et al, 2015). Opportunities for CSA in Central Africa arise from growing but food-insecure population, and for which increasing agricultural productivity does not only enhance food security but also save forest resources. According to FAO (2015), the depletion of forests in the forest-based farming systems in Central Africa has led to large greenhouse gas emissions and loss of ecosystem services. Required are CSA options that limit expansion of cultivated areas into forests or alternatively seek to establish new agricultural production systems that can at the least restore ecosystem services and values through alternative tree crops (Schmidhuber *et al.*, 2009).

In West Africa, adoption of climate smart agriculture in various subsector (crop, fishery and livestock), showed a significant improvement of the current status, climate change impacts, mitigation and adaption strategies (Zougmoré *et al.*, 2016). In addition, it was noted that policy initiatives in the region that foster the development and adoption of climate-smart agricultural options were key in improving resilience of farming systems and livelihoods of smallholder farmers to climate change risks.

To deal with the challenge of a variable climate in the agriculture sector, the Kenyan government has put in place a raft of policies and development programmes in place. Climate Smart Agriculture Project (KCSAP) is implemented by the government of Kenya through the Ministry of Agriculture, Livestock and Fisheries (MoALF). The objective of Climate-Smart Agriculture Project is to enhance smallholder farmers' food security through increased agricultural productivity and household resilience against climate change risks in the targeted smallholder farming and pastoral communities in Kenya. Many studies have pointed to the benefits of climate-smart agriculture in addressing the reality of threats of climate change such as rising average temperatures and changes in rainfall amounts and patterns. For smallholder households that heavily depend on agriculture, adaptation, and mitigation measures, including coping strategies are achievable through climate smart agriculture. The impacts on livelihood outcomes, of Climate Smart Agricultural Practices (CSAPs) that are promoted as adaptive strategies against effects of climate change have been recorded as significant in many parts of Kenya: Nyando basin (Ogada *et al.*, 2020).

Laikipia County is one of the 24 counties in Kenya that are highly affected by climate change (GoK, 2017). Laikipia County is a multi-ethnic county with a substantial number of agro- pastoral and pastoral communities, ranchers, and horticulturalists. The county also hosts numerous wildlife conservancies (Laikipia CIDP, 2013) and comprise of extensive semi-arid lands as well as arable and urban areas. Pressures on water and land resources has greatly gone up in recent years, with increased farming activities, rapid population growth, and periodic drought as well as climate variability (Laikipia CIDP, 2018).

Most households in Laikipia County are food insecure (Laikipia CIDP, 2013. This grim situation calls for regular government intervention in the malnutrition problems through emergency nutrition supplementation food aid (GoK, 2013). For instance, in the year 2017, the World Bank, through the Kenya Climate Smart Agriculture Project allocated Sh44.8 million to 110 groups of Laikipia farmers to boost their empowerment through climate smart agriculture (KCSAP, 2020). The support was also hoped to reduce global warming.

In Laikipia County, Climate Smart Agriculture (CSA) is being promoted by the county government (with co-funding from the Kenyan national government and the World Bank) as an integratede approach to address the challenges of food security and climate change by improving agricultural productivity, food security, and household resilience (FAO, 2010). Most of the interventions of the county government in supporting climate smart agriculture involve farmers' trainings and sensitization. Many technologies and advances in the agriculture sector, such as inorganic fertilizers, pesticides, feeds, supplements, high yielding varieties, and land management and irrigation techniques have been proved as vital in increasing production in Laikipia County (Laikipia CIDP, 2013). Modern technologies in agriculture are important in meeting the food needs of a growing population and in generating economic growth needed for poverty reduction. However, certain circumstances associated with modern agricultural practices and techniques cause ecological damage, degradation of soils, unsustainable use of resources, outbreak of pests and diseases, and health problems to both livestock and humans (Kilewe *et al.*, 2010). Unsustainable land use practices have resulted in lower yields, degraded or depleted natural resources. Poor practices have been a key driver of agriculture's encroachment into important natural ecological areas such as forests. The quest to increase yields without expanding the land size under cultivation has often heightened the vulnerability of production systems to shocks such as outbreaks of pests and diseases, droughts and floods, and changing climate patterns (Hansen, 2002). It is prudent that sustainable approaches to agricultural development such as climate smart agriculture are introduced for promotion through all-inclusive methods such as participatory learning action (PLA) and evaluated with the aim of improving agricultural productivity, building resilience to climate change and mitigating greenhouse gas emissions, especially in the vulnerable semi-arid environments such as Laikipia. The purpose of the study was to assess the contribution of Climate Smart Agricultural Practices (CSAPs) on food security, among smallholder farmers in Laikipia County, Kenya. The study was aided by the hypotheses, "There was no significant contribution of Climate- Smart Agriculture on the household food security status among the household smallholder farmers in Laikipia County, Kenya".

2. METHODOLOGY

This study used correlation research design. The study was carried out in Laikipia County, Kenya. Geographically, the county has three sub-counties (Kenya Constitution, 2010) namely, Laikipia East, Laikipia West, and Laikipia North, and it is the 15th largest county in the country by land size, covering an area of 9700 square kilometres (Laikipia CIDP, 2013).

The target population were 81,710 smallholder farming households in Laikipia County (MoALF, 2022). The accessible population were 74,282 households who were practicing small scale farming in Laikipia County during the 2021/2022 cropping season (MoALF, 2022). This study used a multi-stage sampling technique to obtain a representative sample. In the first stage, the study area was stratified into three sub-counties. In the second stage, five wards were purposively selected (Ngobit and Tigithi wards from Laikipia East Sub-county; Salama and Marmanet wards in Laikipia West Sub-county; and Sosian ward in Laikipia North Sub- county). Systematic random sampling was used in identifying the final study sample where every tenth farmer was selected.

The determination of the sample size followed proportionate to size sampling methodology described by Kothari (2004).

$$n = \frac{z^2 pq}{E^2}$$

$$n = \frac{1.96^2 0.5^* 0.5}{0.05^2} = 384$$

Where;

n = Sample size; Z= confidence level (α=0.05); p = proportion of the population

containing the major interest q = 1-p E= allowable error. Since the proportion of the population is not known, p= 0.5, q= 1-0.5=0.5, Z= 1.96 and E = 5%.

Based on this, a total of 384 smallholder farmers were selected for the study. Table 1 shows the population of 74,282 households of smallholder farmers and the percentage proportion in each sub-county in Laikipia County. It also shows the calculated sample size for each sub-county and the total sample size for the study.

Table 1: Sample Size Selection per Sub-County in Laikipia County

Sub-County	**Households**	**Percent**	**Sample size**
Laikipia East	26,889	36.2%	139
Laikipia West	28,049	37.8%	145
Laikipia North	19,344	26.0%	100
Total	74,282	100.0%	384

Researcher administered questionnaire was used to collect data from the small scale farmers and Key Informant

Interviews (KIIs) were used to collect primary data from sub-county agricultural officers. Experts in community studies and extension and climate smart agriculture from Egerton University and Bomet University College were used to determine the validity of the instrument. The instrument was pre-tested using 30 (thirty) smallholder farmers from Laikipia County. Respondents in the pre-test sample were not part of the final study. The reliability of the questionnaire was estimated using Cronbach alpha coefficient. Using Cronbach's alpha, an index of 0.82 for the questionnaire was established and considered acceptable.

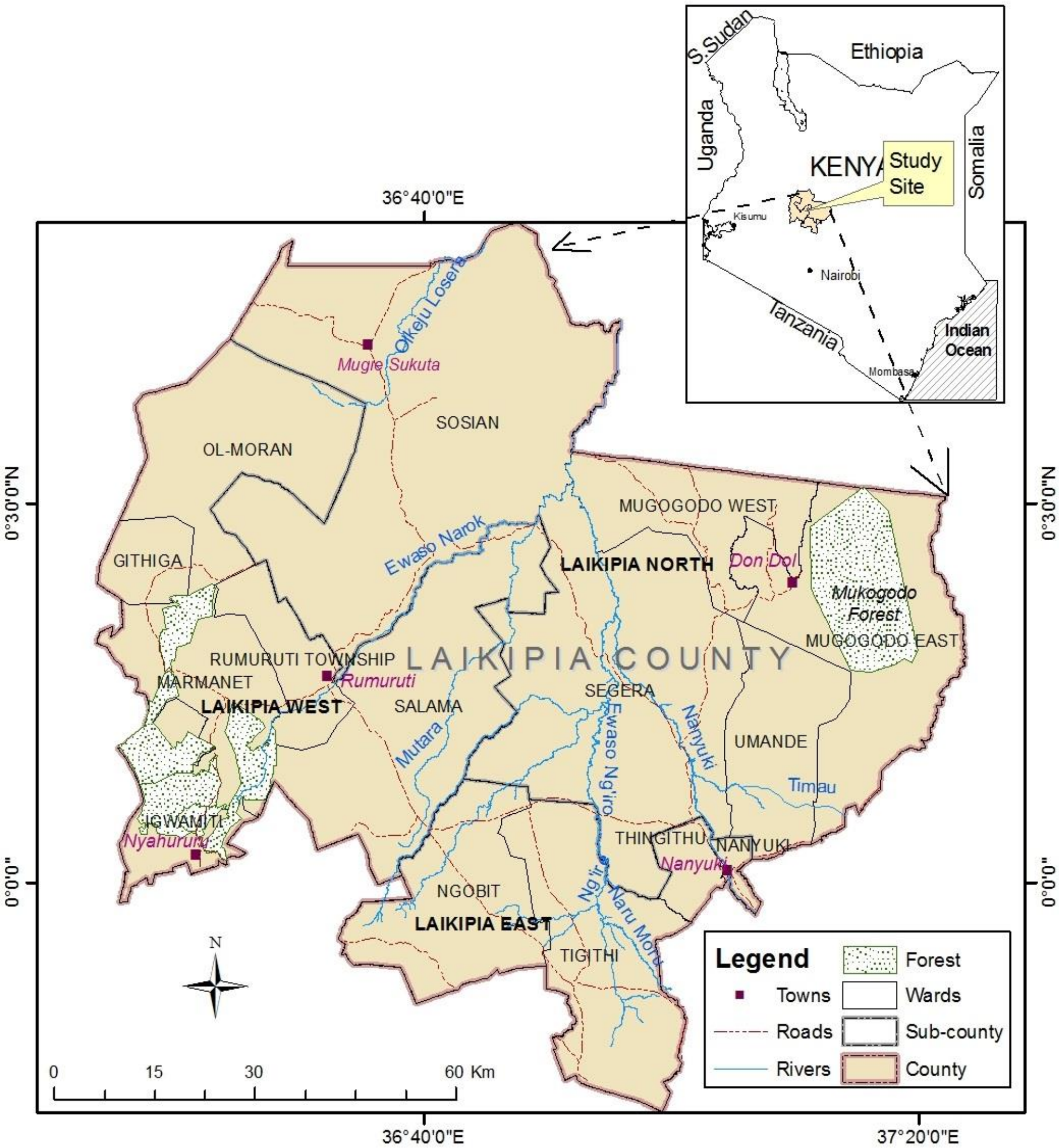

Figure 1: Map of Laikipia County, the study area

Source: State Department of Lands, Laikipia County (2022)

In this study, descriptive and inferential statistics (ordered logistic regression) using Statistical Package for Social Scientists (SPSS) program version 25 was used to analyse data. Food availability was measured using Food Consumption Score (FCS) and Household Dietary Diversity Scale (HDDS).

3. RESULTS AND DISCUSSION

3.1 Demographic Characteristics of Farmers

The study sought information about the demographic characteristics of the 384 respondents. This included gender, age, marital status, level of education and disability status of the household head as well as household size and income sources. Gender distribution showed 55% of the respondents were males. The age of the households showed that most of the respondents were between 31 and 60 years with the majority falling in the 41-50 age group (29.7%) while the least (8%) were between 21 and 30 years.

Table 2: Age Group of the Household Heads

Age Group	Percent (%)
21 – 30 Years	8.3
31 – 40 Years	22.4
41 – 50 Years	29.7
51 – 60 Years	24.7
Above 60	14.8
Total	100.0

The marital status of the respondents was evaluated and the results showed that 71% were married, 12.8% were single, 10.2 % widowed, 3.1% divorced while 2.3 were separated from their spouses. The farmer's residence was assessed and the study showed that most (47.1%) respondents were from Laikipia West, 34.6% from Laikipia East and 18.2% from Laikipia North.

Table 3: Farmers Residence

Farmers Residence	Percent (%)
Laikipia East	34.6
Laikipia West	47.1
Laikipia North	18.2
Total	100.0

The farmer's duration of settlement in the land was assessed (Table 4).

Table 4: Farmers Length of Settlement in their Land

Length of Settlement	Percent
Less than 5 years	8.1
5 - 10 years	20.8
11 to 15 years	22.4
16 to 20 years	19.8
Above 20 years	28.9
Total	100.0

Majority of the farmers length stay (settlement) in the land was above 20 years (28.9%). About 8.1% of the farmers had lived on their present land for less than five years.

The Agro-Ecological Zone (AEZ) of the respondents was assessed and the findings summarized in Table 5.

Table 5: Agro Ecological Zones

Agro Ecological Zone	Percent
LH4 Cattle & Sheep Ng'arua	20.8
LHS Lower Highlands Reaching Zones Rumuruti Ng'arua	39.6
UM5 Livestock & Sorghum Zone	30.2
UM6 Upper Midlands Reaching Zone	9.4
Total	100.0

Majority of the respondents were located in LHS (Lower Highlands) Agro-Ecological Zone as represented by 39.6% of the total responses. This was closely followed by respondents from UM5 (Livestock & Sorghum zone) Agro-Ecological Zone as represented by 30.2% of the total respondents. About 20.8% and 9.4% of the respondents were located in LH4 (Cattle & Sheep) and UM6 (Upper Midlands Reaching) Agro-Ecological Zones. The differences in Agro-Ecological Zones implies that a variety of crops could be supported.

The respondents were categorised by their level of education (Table 6).

Table 6: Respondents Level of Education

Level of Education	Percent
Primary School	8.1
High School	26.8
Diploma	45.6
Degree	13.3
Masters	6.3
Total	100.0

Most (45.6%) of the respondents had diploma level of education. About 26.8% of the respondents had high school level of education. There were few respondents with primary, degree and master's level of education. These results imply that majority of the farmers may possess adequate formal education which is necessary for better farming and adaptation to climate change. In addition to this, the level of education of the household head can influence the kind of decision that may be made on behalf of the entire household with regard to climate smart agriculture. More educated farmers are likely to make better decisions as well as quickly adopt new technologies in farming as compared to their less educated counterparts.

Majority (68.8%) of the respondents had a household size of 1-5 members, with 30.4% having a household size of 6-10 members while 0.8% had 11 and above household members (Table 7).

Table 7: Household Sizes

Household Size	Percent
1-5	68.8
6 – 10	30.4
11 and above	0.8
Total	100.0

The mean household size of the respondents was 4.84 members, which was slightly higher than the national average of 3.9 members (KNBS, 2019). Household composition is critical in determining labour availability and can influence several labour-intensive farming activities. Households with fewer members are more likely to miss family labour as compared to households with more. In places where majority of farming activities are labour intensive, households with more members can operate at a higher level of efficiency as compared to households with less members.

3.2 Contribution of Climate-Smart Agriculture on Household Food Availability among Smallholder Farmers

This study sought to evaluate the contribution of climate smart agriculture on household food availability among smallholder farmers in Laikipia County, Kenya. Selected practices included water harvesting, pest and disease control, conservation agriculture, agroforestry and diversification of production systems.

Table 8: Climate-Smart Agricultural Practices

CSAPs	Percent
Water harvesting and use	72.9
Pest and disease control	90.6
Conservation Agriculture	72.9
Agroforestry	58.3
Diversifying production systems	83.3

Majority of the CSAPs under investigation had been adopted by the respondents. The adoption for the selected CSAPs that had highest adoption was pest and disease control (90.6%) followed by diversification of production systems (83.3%) (Table 8).

The most implemented water harvesting and use practices among the sampled farmers included manual watering of crops (bucket) (56.0%) followed by water storage through pools, dams, pits and retaining ridges (50.0%) (Table 9).

Majority of the farmers who had adopted pest and disease control practices had embraced use of pesticides/fungicides (79.9%) followed by pest/disease tolerant varieties of crops (65.1%) (Table 9).

Table 9: Specific Forms of CSAPs Implemented by Respondents

CSAPs	Specific CSAPs	Percent
Water harvesting and use	Water storage through a pool/dams/pits/retaining ridges, etc.)	50.0
	Practice water-use efficiency (e.g. drip irrigation)	22.4
	Manual watering of crops (bucket)	56.0
Pest and disease control	Adopting new drought tolerant varieties of crops	54.7
	Adopting pest/disease tolerant varieties of crops	65.1
	Biological weed control	47.9
	Companion planting	59.6
	Use of pesticides/fungicides	79.9
	Others	9.4
Conservation Agriculture	Minimal mechanical soil disturbance (i.e. minimum tillage and direct seeding)	51.3
	Mulching	62.0
	Rotations or sequences and associations of crops.	74.5
Agroforestry	Planting and maintenance of trees and shrubs	48.7
	Others	6.3
Diversifying production systems	Keeping of livestock as well as growing of crops	83.1
	Growing of different types of crops	86.7
	Engagement in both farm and off-farm activities	62.5

Some of the farmers implemented Conservation Agriculture (CA) practices most of whom used rotations or sequences and associations of crops (74.5%) (Table 9). Agroforestry was practised by less than half of the respondents.

The most implemented diversification practice among the farmers was growing of different types of crops (86.7%) followed by keeping of livestock as well as growing of crops (83.1%).

Using a 24-hour recall period, this study sought to determine the households' dietary diversity by assessing consumption over the reference period. A total of 16 food groups were assessed that included Cereals/grain, roots/tubers, legumes/nut, orange vegetables (vegetables rich in Vitamin A), green leafy vegetables, other vegetables, orange fruits (fruits rich in Vitamin A), other fruits, meat, liver/kidney/heart/other organ meats, fish/shellfish, eggs, milk/other dairy products, oil/fat/butter, sugar/sweet and condiments/spices.

Households who participated in this study had their food security scores computed (Table 10).

TABLE 10: FOOD SECURITY SCORES

Food security scores	Obs	Mean	Std. Dev.	Min	Max
FCS	384	8.50	4.78	1	25
HDDS	384	3.92	2.01	1	11

With respect to Food Consumption Score (FCS), an average household in this study scored a mean of 8.50 (standard deviation = 4.78). On the other hand, with respect to Household Dietary Diversity Scale (HDDS), an average household in this study scored a mean of 3.92 (Std. Dev. = 2.01).

Based on the respondents scoring on Household Dietary Diversity Scale (HDDS), the household food availability was categorized into five groups (Very low, Low, Moderate, High and Very high) (Table 11).

Table 11 shows that a cumulative of 64.3% had low to very low food availability levels. There were very few households who had high to very high food availability levels.

Table 11: Household Food Availability Levels

Food availability levels	Percent
Very low	28.1
Low	36.2
Moderate	24.0
High	9.1
Very high	2.6
Total	100.0

The log likelihood for the fitted model of -514.42 and the likelihood ratio chi-squared value of 31.20 at one degree of freedom (Prob> chi2 = 0.000) indicate that the two parameters are jointly significant at 5%. Pseudo R^2 of 0.294 meet the statistical threshold confirming that food availability was well attributed to the independent variables considered in the model (climate-smart agriculture).

Table 12: Contribution of Climate-Smart Agriculture on Household Food Security Status

Food availability	Coef.	Std. Err.	Z	P>z	[95% Conf.	Interval]
Climate-Smart Agriculture	0.400	0.073	5.460	0.000	0.257	0.544
/cut1	0.511	0.287	0.051	1.073		
/cut2	2.147	0.309	1.541	2.752		
/cut3	3.632	0.341	2.964	4.300		
/cut4	5.246	0.442	4.380	6.112		

Note: n =384; LR chi2(1) = 31.20; Prob > chi2 = 0.000; Log likelihood = -514.42; Pseudo R2 = 0.294

The results in Table 12 reveal that the coefficient for Climate-Smart Agriculture (0.400) was positive and statistically significant at 5%. This implies that Climate-Smart Agriculture significantly improved household food availability.

The findings of this study agree with Lipper *et al.* (2014) and FAO (2013) who separately reported that climate-smart agriculture (CSA) is a pathway to the improvement of food availability in a changing climate. According to Lipper *et al.* (2014), CSA is an approach for transforming and reorienting agricultural systems to support food availability under the new realities of climate change. In a changing climate, CSA can sustainably enhance the achievement of national food availability (FAO, 2013).

The findings of this study also agree with Branca *et al.* (2021) who found that CSA practices can increase crop productivity and thus contribute to food availability. Food availability in an era of climate change may be possible if farmers transform agricultural systems by use of means such as improved crop seed and fertilizer (Branca *et al.*, 2021).

This study is also consistent with FAO (2010) that asserted that Climate Smart agricultural practices and more efficient resource use agricultural production systems offer considerable potential for increasing household food availability. With the right practices, policies, and investments, the agriculture sector can move into CSA pathways, resulting in decreased food insecurity and poverty in the short term while contributing to reducing climate change as a threat to food security over the longer term.

Study Limitations

Climate smart agriculture is a broad concept that entails several integrative approaches to address the challenges of climate change and food security. However, this study only considered water harvesting and use; conservation agriculture; agroforestry; pest and disease control; and diversification practices. Food security entails food availability, food access, food utilization and food stability. Instead of all the four aspects of food security, this study only considered food access and availability.

4. CONCLUSION AND RECOMMENDATIONS

Climate smart agriculture improved food availability significantly hence better household food security in the study area. Through climate smart agriculture, farmers stand a higher chance of producing more food as well as possibilities of greater income (financial resources) necessary for purchasing foods that are not grown on their farms. Smallholder potato farmers who have not implemented CSAPs recommendations should be encouraged to start practicing due to its positive contribution to food security. Efforts to enlighten farmers on how best to practice the selected CSA recommendations is also timely through extension services and technical trainings. Decision- and policy-makers in smallholder farming would benefit from the study since it may aid in developing policy guidelines in line with the achievement of the Sustainable Development Goals (SDGs) number thirteen which seeks to effect sustainable and effective climate change actions as well as SDG -2 (zero hunger). The findings of this study would act as a base for more research on contribution of Climate Smart Agricultural Practices (CSAPs) on food security, among smallholder farmers in Laikipia County, Kenya. This study was not exhaustive and recommends further research on how CSAPs influence household food security in the study area through six dimensions (availability, economic and physical access to food, food utilization, food stability, agency, and food sustainability).

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