# Contribution of Climate-Smart Agricultural Activities to Household Livelihoods in Masii Ward, Machakos County, Kenya

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## ABSTRACT

*Climate-Smart Agriculture (CSA) is an approach that seeks to achieve three outcomes, which include increasing productivity, enhancing resilience, and reducing GHG emissions. It is pivotal in the context of Climate change-induced vulnerabilities. To ensure food security amidst climatic change-induced vulnerabilities, it is essential to incorporate CSA activities that will increase food production, enhance resilience to unpredictable weather patterns, and mitigate greenhouse gas emissions. The study sought to assess the contribution of CSA activities to household livelihoods in the Masii ward of Machakos County, Kenya. Two theories guided the study: the theory of change by Anderson (2005) and the hierarchy of needs theory by Abraham Maslow (1943). The research design for the study was a descriptive research design, and the study was conducted in Masii ward, Machakos County. The target population for the study was household heads practicing CSA. The extension officer of the ward and KCSAP officials made up the key informants for the study. Cluster random sampling was used to get the study sample. A sample size of 281 household heads was used as a representative sample from a total of 939 households in the ward that have already been funded by the CSA project. The farmers were already in groups consisting of between 20 and 35 members. Since they didn't contain an equal number of people, proportional allocation was used to select the study sample. Purposive sampling was used to select key informants who took part in the study. Interview schedules were used to collect data from the household heads and the extension officer, whereas focus group discussions were held with the KSCAP officials. Qualitative data was coded for ease of analysis, whereas quantitative data was run through the SPSS program to generate the required data, such as summary statistics such as means and percentages. The findings show that CSA has truly had a positive impact on household livelihood in terms of enabling the farmers to cater to their essential needs, maintain nutritional uptake, and get surplus income to cater to their other needs. Households are able to afford a balanced diet due to increased plant and animal productivity and the availability of surplus income. If CSA is embraced by more people, it will for sure help in alleviating hunger, especially in these times when climate change is a main issue due to its unpredictability. In the long run, the whole community will have benefited from the improved agricultural practices. Besides, if the CSA activities are consistent, it will achieve its three pillars, which are adaptation, resilience, and mitigation of greenhouse gases. Based on the study's findings, the study recommends that sensitization on CSA continue so as to create more awareness about it and enable more farmers to embrace it. Youth should be encouraged by the government to venture more into agriculture since the agricultural benefits accrued can be a source of livelihood for the unemployed. Additionally, the success stories of the youth already reaping from agriculture can be shared to serve as motivation for others that indeed it is possible to make a living from agriculture.*

**Keywords:** Climate-Smart Agriculture; Climate Change; Household Livelihoods; Masii Ward; Machakos County

## I. INTRODUCTION

Food security around the world has declined in the recent past due to various challenges such as poverty, community conflicts, socio-economic conditions, and climate change. The COVID-19 pandemic has further deteriorated the socio-economic progress of vulnerable communities, making the 2030 vision of achieving zero hunger far-fetched. Agriculture is an essential factor in promoting food security, as it contributes significantly to the Gross Domestic Product (GDP) of most African countries and has several benefits such as job creation, productivity increases, income generation, and poverty reduction. Climate change has resulted in the vulnerability of agriculture, as it is dependent on weather conditions to thrive. Innes et al. (2015) states that the unfavorable effects of climate change have resulted in low crop and livestock productivity, especially in developing countries. This study reveals that high temperatures due to climate variations have impacted crop production, leading to food insecurity. The IPCC report states that climate change is causing a variety of changes in various regions, all of which will worsen as temperatures rise further. The greenhouse effect is the main driving force behind climate change, as gases in the air heat the atmosphere and the earth's troposphere (the lowest layer of the atmosphere). Carbon dioxide is the largest contributor to the greenhouse effect, as it lowers protein and mineral concentrations in plants. Studies by Pearson et al. (2017) indicate that human activities have resulted in a rise in greenhouse gases, which has resulted in global warming.

Other studies show how climate change has affected crop yield all over the world, such as through low rainfall and high heat, and that increasing sea levels pose a new threat to food security in Bangladesh and Vietnam. Nguyen et al. (2018) report that a flood in this area might significantly contribute to food insecurity, as a one-meter rise in sea level would submerge large areas of rice paddies. A study by Serdeczny et al. (2017) reports that most areas in the Horn of Africa are arid and semi-arid and are characterized by cycles of droughts and flooding, leading to food insecurity. Southeastern Ethiopia, northern and coastal Kenya, and almost all of Sudan were the most affected by the 2017 drought. Kenya is a country in East Africa situated along the equator with varying climate conditions, with the central and western highlands being the most productive due to their temperate climate with medium-to-high rainfall.

Droughts experienced in most parts of the country affect food security and the economy of the country. People living in the arid north areas of Kenya are the most affected by food insecurity due to the droughts that are prevalent in the region, and cases of malnutrition among children are high in these regions due to inadequate food and water supplies. A study by Ochieng et al. (2016) also states that the poor, especially small-scale farmers, are most affected because they lack means of diversifying their income sources. Climate-Smart Agriculture (CSA) is a method that seeks to increase productivity, enhance resilience, and reduce GHG emissions. It is unique in that it considers the link between productivity, adaptation, and mitigation in a systematic manner and seizes new funding openings in order to close the investment gap.

CSA methods are primarily targeted at maintaining both sustainability and agricultural intensification, which are both important for increasing production and providing food security. Risk insurance and the use of climate data in farming are examples of CSA techniques, as are agroforestry, better fodder production, tree nurseries, manure management, and composting. Other strategies include agroforestry and carbon trading, water harvesting and water management practices, using improved seeds and fertilizers, using drought-resistant crops, crop rotation, crop diversification, adopting improved technologies, and economic diversification into non-farm activities (Wekesa et al., 2018). The most important details in this text are that non-forestry activities such as using renewable sources of energy, seeking off-farm employment, changing the planting days, and having a mixed livestock herd are examples of CSA in action. There are still policy, knowledge, and capability gaps and financial setbacks to promote their adoption, and Africa is still behind in implementing the UN's Sustainable Development Goal (SDG) 2 (Atukunda et al., 2021). To achieve food security, farmers must be aware of the climatic changes so as to identify the best adaptation strategies and put them into practice for effective adaptation and mitigation. There is a need to embrace CSA based on the expected effects of climatic fluctuations on agriculture to tackle food security issues while also addressing climate variability.

The pertinence of CSA in Kenya cannot be taken for granted. The country has been dealing with food insecurity in recent years. According to the "Integrated Food Security Phase Classification (IPC) acute food insecurity and acute malnutrition analysis, July 2021ngJanuary approximately 2.1 million people in the country living in arid and semi-arid lands are food insecure (Reliefweb, 2021). One important area to take into account while tackling the challenge of food insecurity is the agricultural industry. As USAID reveals, this is because it constitutes 33% of Kenya's GDP and a large percentage of people living in the rural areas depend on agriculture as a source of livelihood (USAID, 2021). Since agriculture is mainly rain-fed, the ongoing drought and short rains are worsening the food insecurity issue, hence the need to invest in agricultural-related initiatives.

Extant literature shows that arid and semi-arid lands in the world, including Kenya, are usually prone to food insecurity (WFP, 2023). This is mainly caused by various factors such as drought, pests, and unfavorable climatic conditions (USAID, 2021). This has resulted in low agricultural yields and food insecurity. Additionally, studies have shown that advancement in technology and innovation in agriculture across the world can enhance food production and security. In Kenya, climate smart agriculture (CSA) is a strategy whose goal is attaining food security through improved agricultural productivity. Having been implemented in Kenya since 2017 in various counties, there is a need to evaluate its role with regard to food security. Thus, the need for this study, which focuses on assessing the contribution of climate-smart agricultural activities to household livelihoods in Masii ward, Machakos County, Kenya,

### 1.1 Objectives of the study

To assess the contribution of CSA activities to household livelihoods in Masii ward, Machakos County

## II. LITERATURE REVIEW

### 2.1 Empirical Review

A report by the Food and Agriculture Organization (FAO) states that climate-smart agriculture came to light in 2010 at a FAO meeting at the Hague Conference on Food Security and Climate Change (FAO, 2010). It further

states that CSA aims to promote food security while at the same time ensuring the environment is not at risk. Therefore, there exists a relationship among all three CSA pillars. The report adds that through CSA activities, adaptation becomes effective (FAO, 2010). A study by Nyasimi et al. (2017) sheds light on how practicing various CSA activities, such as field management and accessing climate information services, puts one a step closer to achieving CSA goals. Likewise, a study by Rosenstock et al. (2019) adds that other CSA activities include crop diversification, using resilient, stress-tolerant seeds, water and waste management, and cross-breeding of livestock. Of importance to note is that diversification of cropping systems not only protects smallholders from food insecurity but also adds to dietary diversification and elevates farm income, as revealed by Wainaina et al. (2017).

Another study by Kallio (2013) shows that trees planted alongside crops have several uses. For instance, they can be used as medicine, fruits, to make poles to build with, or as a source of fuel. Other authors report that these items can either be consumed at home or sold for profit (Karwani et al., 2016). The extra money can be used to buy a wider range of foods that aren't grown on farms, expanding the variety of food available to households. Additionally, other literature reports that the availability of various sources of fuel, such as wood and biogas, enables households to cook a range of foods (Dawson et al., 2014).

Wainaina et al. (2017) likewise state that under climate variability, climate-smart agriculture can improve food security by increasing agricultural income through higher yields or by freeing up labor for alternate economic pursuits. On the other hand, studies have shown that agriculture largely contributes to GHG emissions through agricultural activities and alterations in land use (Ronaghi et al., 2018). These studies, in addition, state that GHGs are emitted through fertilizers, excretions from animals, methane production from rice cultivation, and nitrous oxide gases from soils (Ronaghi et al., 2018). Therefore, in order to curb this, carbon IV oxide emissions need to be reduced by 45% by 2030 (IPCC, 2018). Additionally, proper mitigation efforts such as photosynthesis, proper land use through planting perennial crops, minimal tillage, and carbon sequestration are essential (Garca-Marco et al. 2016).

A report by the IPCC states that planting perennial crops rather than annual crops has resulted in a 50 percent to 100 percent increase in soil carbon; since soil is the world's third largest carbon reservoir; it is paramount to maintain it for mitigation purposes (IPCC, 2018). This is due to the fact that perennial crops have deeper roots and require less tillage, thus improving the quality of the soil and sequestering carbon at the same time. A study by Lawrence et al. (2018) defines carbon sequestration as a situation whereby plants absorb carbon dioxide, thereby reducing global warming. This is attained through photosynthesis. This study also states that reducing carbon emissions among livestock is directly proportional to increasing their productivity. Lawrence et al. (2018) On the other hand, a study by Chanthakhoun et al. (2011) reports that one way of reducing the emissions is by feeding legumes to animals; legumes have less fiber and hence emit less methane as compared to other feeds. Other literature reveals that deworming livestock eradicates infestation by internal parasites, thereby increasing their productivity and, as a result, reducing their emissions (Kumar et al., 2013).

A study by Chitongo et al. (2019) sheds light on how the cyclone Idai in March 2019 in Mozambique negatively impacted farmers. The study reports that farmers who had diversified the type of rice they planted were adaptive and resilient to climate change and, hence, did not suffer from food insecurity issues compared to their counterparts who didn’t take any CSA measures. In addition, the farmers who had used fertilizers at the required time and amount suffered less compared to their counterparts who didn’t take any CSA measures.

FAOSTAT (2017) reveals that in Africa, maize is the staple food for most people, but its yield has gone down in recent years. To counter this, another report by FAO reveals that the use of drought-tolerant maize varieties and hybrids has resulted in an increase in yield of approximately 35%. FAO and ICRISAT (2019a) report that in north-east Nigeria, FAO has trained a number of people on CSA methods and launched a program called Safe Approach to Fuel Energy (SAFE). This report reveals that this program attempts to decrease greenhouse gas emissions by reducing the amount of firewood used. The report further sheds light on the Pro-Resilience-Action (PROACT) project in Nigeria, which started in 2016, as an example of how CSA expertise has helped farmers become more resilient. This project was brought to life as a result of the collaboration of the European Union and Oxfam Nigeria. It provides farmers with training in rural investment and the establishment of organizations to enable them to access banking services, as well as farm inputs such as fertilizers and water pumps. It is currently being implemented in Adamawa State (Mubi South, Song, Fufore, and Guyuk). The report also states that training was not only done to farmers but also extension officers in Adamawa and Kebbi States to make them aware of agricultural practices that boost production (FAO and ICRISAT 2019a). As a result of these measures, the report reveals that farmers have seen an improvement in rice production. It further adds that to abate desertification, the project intends to encourage farmers to plant 500,000 trees. In addition, terracing is being practiced in the rocky region of Bono State, a CSA practice that has reduced soil erosion as reported by FAO and ICRISAT (2019a).

A study by Abdullahi (2023) in Kenya revealed that the Kenya Climate Smart Agriculture Project (KCSAP), with funding of 300 million shillings from the European Union (EU), has implemented CSA in the country. Its goal is to fund 40 smallholder farming groups in various counties practicing CSA projects, for example, farming, livestock keeping, and fishing (Abdullahi, 2023). Climate smart villages are a concept introduced and implemented in various countries in Africa, Kenya being one of them, as indicated by Ojango et al. (2016). Its aim is to increase productivity and resilience to climate risks (Ojango et al., 2016). Various CSA approaches differ depending on the ecological zones; therefore, researchers and community representatives get to decide which approach best suits them. This study by Ojango et al. (2016) reveals that climate smart villages use a participatory approach and incorporate women and vulnerable communities to take part in the process. The same study reports that the CSV project has seen farmers in Nyando incorporate new ways of farming by practicing crop diversification. The establishment of a seed bank in the region ensures farmers have access to a variety of sorghum, millet, and bean seeds that have been tested for resilience by the Kenya Agricultural and Livestock Research Organization (KALRO) and Bioversity International, as reported by CGIAR (2019). The CGIAR (2019) report also states that farmers have also undergone training workshops where they are taught financial management and marketing strategies, which are fundamental for the accomplishment of their seedbank project. The report additionally states that through this, the farmers have supplemented their income (CGIAR, 2019). This guarantees that if climate change risks occur, they will not incur total losses.

Another study by Grossi et al. (2019) states that to ensure continuity of productivity even during dry seasons, farmers have adopted the use of hay, which is dried grass. In so doing, livestock still get to eat efficient and nutritious feeds, and their overall productivity is maintained. On the other hand, Ojango et al. (2016) reveal that utilizing animal excrements and planting nitrogen-fixing crops decreases nitrous oxide outflows; thus, utilizing natural manures expands the carbon and nitrogen parts of the soil, making it more fruitful.

Manure management using alternate sources of fuel, such as biogas instead of firewood, ensures trees are protected, as indicated by a study by Ojango et al. (2016). Moreover, rotational grazing, too, is CSA in action in that it ensures regeneration of land (Ojango et al., 2016). In addition, to ensure soil fertility is retained for better productivity, the farmers are also practicing agroforestry, as stated in a report by the Government of Kenya (GoK, 2018). A study by Kristjanson et al. (2017) reveals that community-based organizations (CBOs) in the region have given the farmers a platform to get the money they need to buy farm inputs at reasonable costs. Accessibility of water ensures plants and livestock get enough water needed for maximum productivity. Ojango et al. (2016) report that the CSA also guarantees water accessibility through harvesting rainwater and the use of efficient irrigation systems.

Despite CSA efforts, Wiederkehr et al. (2018) disclose that there are limitations to evaluating adaptation and mitigation with regard to small-scale farming since studies tend to dwell on arid and semiarid areas. Studies also show that GHG estimators are lacking since the same GHG calculators are used in Africa, Asia, and Latin America, yet the regions differ in terms of soil topology and climate (Richards et al. 2016). In conclusion, Fraval et al. (2019) state that increasing production alone does not guarantee food security. For example, encouraging the production of one type of crop and failing to diversify the crops means the ingested food is not a balanced diet, which may cause malnutrition and hence food insecurity (Fraval et al., 2019). This implies that for the CSA to be effective, it ought to broaden its dimensions of food security beyond production (Campbell et al. 2016).

### 2.2 Theoretical Framework

The study will be guided by two theories: the Theory of Change by Anderson (2005) and the Hierarchy of Needs Theory by Abraham Maslow (1943). According to Stein and Valters (2012, p. 5), the theory of change is practical in that it outlines steps needed to be implemented for the attainment of a set objective, be it long-term or short-term. Hence, it is essential for our topic under study. Our aim is to ensure household sustainability amidst climate changes that are unpredictable and therefore beyond our control. Therefore, for example, to attain food security, we have to incorporate strategies that we can manipulate. This is where climate-smart agricultural activities come in. Although some of the strategies to be implemented are beyond the scope of agriculture, like water management and insurance services, forming synergies with such sectors is one way of working towards the set objective, which is household sustainability. One thing to bear in mind during this process is to articulate assumptions. This refers to the necessary conditions for success to be accomplished. For instance, for our topic of evaluating the influence of the CSA project in influencing household livelihoods in Masii ward, a practical assumption is that climate change will continue to bring floods, droughts, and unpredictability of rains. Because of this assumption, there is a need to modify farming practices in order to be food secure even in the midst of adverse climate changes. This will further help shed light on why some farmers may or may not adopt CSA activities, and through this, help come up with strategies that are specific to farmers in a certain region.

This study is also pegged to the hierarchy of needs theory. Maslow argues that what people do to increase productivity is guided by what motivates them (Jonas, 2016). That the needs of people vary in terms of importance and are divided into self-actualization, self-esteem, sense of belonging, safety, and physiological needs (Jonas, 2016). Assuming the hierarchy of needs theory, then a farmer's choice of strategy is directly proportional to the benefits it generates. This theory is applicable to this study since it illustrates how the adoption of CSA is a result of wanting to fulfill the household livelihood security need, which is being threatened by climate change. Using Maslow's theory, studies argue that for the fulfillment of people's needs, they need sources of income. With regard to this study, for the attainment of food security, farmers need income sources, and income availability is determined by factors like education level, household size, and off-farm activities to be able to purchase farm inputs and diversify their income sources. Where income is limited due to household size, a priority is made on which needs are to be satisfied first (Damij et al., 2015).

## III. METHODOLOGY

### 3.1 Research Design

The descriptive research design guided the study since; through it the variables under study were just observed and measured without being manipulated. This design was appropriate for this research since, according to Creswell and Creswell (2017), it aims to obtain data that characterizes current events by asking questions about people's perspectives. The descriptive design, according to Lewis (2015), is focused on determining the link between variables. Thus, it will enable the researcher to establish the link between food security and climate-smart agriculture.

### 3.2 Location of the Study

The study location was Masii ward, which is in Mwala Sub County, a semi-arid region as shown in Figure 1.

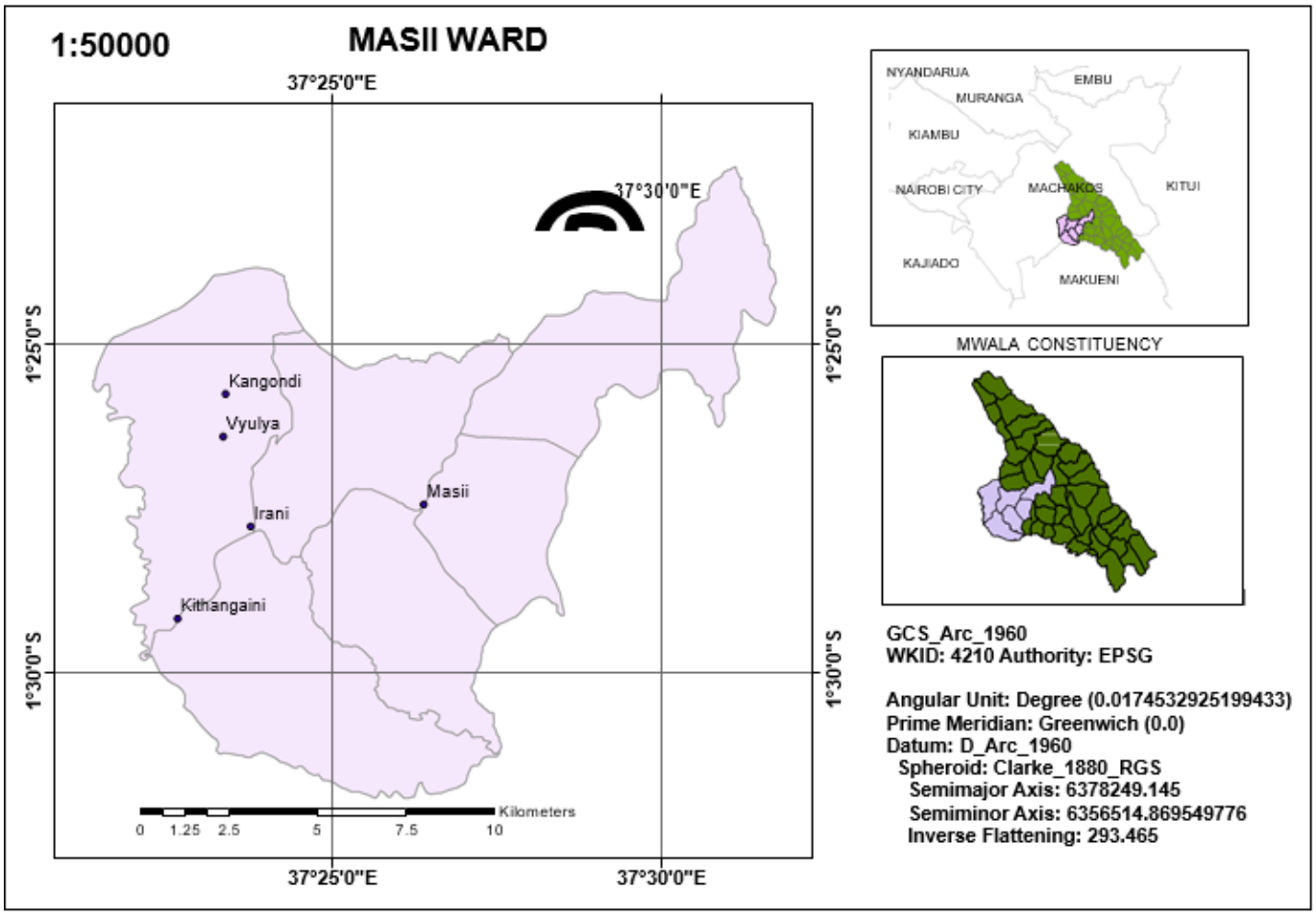


**Figure 1**
*Map of Masii Ward*

The study area (Figure 1) has a population of approximately 32,367 and an area of approximately 160.80 square kilometers. The ward comprises Muusini, Uuni, Mithini, Mbaani, Utiithini, embui, Kavumbu, Kithangani, and Mithanga sub locations. According to the Kenya National Bureau of Statistics (KNBS, 2013), people in the Mwala sub-county majorly depend on agriculture for survival, and the main crops planted are maize, beans, cow peas, pigeon peas, and mangoes. Livestock reared includes chickens, cattle, goats, donkeys, and pigs. Temperature ranges in the region are from 18 to 29 °C (Machakos County, 2015). The main agro-ecological zones (AEZ) fall under the lower midland zones LM2 and LM3, and agriculture is mostly small-scale. Mwala sub-county was chosen as area of study because Machakos County is among the 24 counties in Kenya where a climate-smart agriculture project with funding from the Food and Agriculture Organization has been implemented.

### 3.3 Target Population

The study targeted farmers in Masii ward, Mwala Sub County. Statistics reports from the Kenya Population and Housing Census (KPHC) 2019 by the Kenya National Bureau of Statistics (KNBS) indicate that the number of households in Mwala sub county is 45,840, with an average household size of 3.3 (KNBS, 2019). In Masii ward, 100 farmer groups are registered. These groups are the ones being used for the KCSAP project in the ward. As at the time of data collection, 32 groups out of 100 had already benefited from CSA. Hence, they constituted the population under study. These groups contained a total of 939 people, with each group having a total of between 20 and 35 people. In addition, key informants were part of the study, and they included the extension officer of Masii ward, the county director of agriculture, as well as KCSAP officials in the county.

### 3.4 Sampling Procedures and Techniques

The study used multistage sampling techniques. First and foremost, the purposive sampling technique was used to sample Mwala Sub-County. This is because it is one of the sub counties where climate-smart agriculture activities are being practiced and documented by the agricultural officers in the region. Due to the high number of farmers and limited time frame, Masii ward was selected as a representative of the county since it is one of the wards where CSA has been documented. The existing farmer groups were used as clusters. Proportional allocation was used to calculate the study sample because the groups did not contain an equal number of people. Additionally, purposive sampling was used to select the key informants: the extension officer in the ward, the county director of agriculture, and KCSAP officials.

### 3.5 Study Sample

Household heads were the main respondents of the study. Key informants comprising of extension officer, the Count Director of Agriculture and KCSAP officials were part of the study. The Yamane (1973) formula was be used to generate the sample size where N is population size, n indicates sample size; P represents the degree of variability (0.5) and e the sampling error (5%).

$n= N/(1+N(e)^2)$

Therefore, the sample size used for the study was;

$$n=\frac{939}{1+939(0.05)(0.05)} = 281.$$

Simple random sampling was finally be used to select the respondents from each cluster. A set of random numbers, which identified the sample size to be sampled, was drawn. Sampling was done without replacement and each element is sampled only once.

### 3.6 Proportional Allocation

Since the number of farmers in each group was not equal, proportional allocation was used to select the sample from each group. The formula for proportional allocation is as shown below;

$$\frac{N_i}{N} * n = n_i$$

Where $n_i$ is the sample in the $i^{th}$ cluster,
**N** is the total population,
$N_{i\ is}$ thesize and
**n** is the sample size.

Table 1 illustrates the proportion allocation of the 32 groups. The table 2 below summarizes the sample size used in the study.

**Table 1**
*Sample Size*

| Respondents | Target population | Sample size |
|---|---|---|
| Farmers | 939 | 281 |
| Extension officers | 1 | 1 |
| Key informants | 4 | 4 |
| **Total** | **944** | **286** |

### 3.6 Construction of Research Instruments

The study used structured interview schedules to collect data. This was so as to ensure that the data collected took into account the objectives of the study. With the help of a research assistant, household heads were asked a set of questions. This method was most appropriate since it considered the farmers who were illiterate. In such instances, an interpreter was sought. Through interview schedules, farmers got to seek clarity from the enumerator in instances whereby they had not understood the questions asked. This made the data collection process more accurate. Interview schedules were also used to collect data from the extension officer in the ward. For the other key informants; KSCAP officials, focus group discussions were used guided by structured questions. The aim of conducting focus group discussions with key informants was to not only gather in-depth knowledge of the need to embrace CSA amidst the adverse climate changes but also provide insight to policies and institutional strategies set in place at the county and national level to deal with climate change in a bid to ensure food security. The discussion also shed light on the institutional capability of dealing with adverse climate change effects.

### 3.7 Testing for Validity and Reliability

Validity and reliability are crucial factors to consider when choosing a survey instrument.

#### 3.7.1 Validity

Expert advice from the supervisor was sought to ensure that the questions in the interview schedule address the given objectives. Content validity was used to determine whether the data collection instruments are structured in such a way that the questions asked are linked with the objectives under study. To measure the content validity index, Lawshe (1975) proposed a formula to quantify content validity ratio.

Content Validity Ratio = $(n_e – N/2) / (N/2)$

where:

- $n_e$**:** The number of subject matter experts indicating “essential”
- N: The total number of panelists who are experts of the subject matter.

If the content validity index is closer to 1, then the higher the validity of the test that is an overall content validity index of 0.8 and above shows that the test is valid.

#### 3.7.2 Reliability

Reliability on the other hand involves consistency in measurement. This was done through a piloting study in Kajiado County, Kajiado North Sub-County since it has similar climatic condition as Machakos. The aim of the pilot study was to determine whether the data collection instruments would be effective during the actual data collection exercise. According to Orodho (2003), a pre-test takes into account 10% of the study sample size thus 29 respondents took part in the pilot study. The reliability of the test was determined by the Cronbach alpha (the reliability coefficient) using the SPSS program. An average Cronbach alpha value of between 0.7 and 1 is considered reliable. All the recommendations from the pre-testing exercise were taken into consideration and changes made appropriately.

### 3.8 Data Collection Methods and Procedures

Data collection commenced by conducting interviews with household heads. Afterwards an interview schedule was used collect data from the extension officer in Masii ward. Photos and audio recordings were taken via phones. In addition, focus group discussions were used to collect data from the County Director of Agriculture and officials of the KCSAP project in Machakos County.

### 3.9 Data Analysis Techniques and Procedures

The data collected from interview schedules and focus group discussions was both qualitative and quantitative in nature. Qualitative data was coded to ease the analysis exercise using descriptive statistics. Data entry was done in excel then exported to Statistical Package for Social Scientists (SPSS) version 21 for analysis. The descriptive statistics that give fundamental details about variables in given datasets is displayed in tables and figures.

## IV. FINDINGS AND ANALYSIS

### 4.1 Background Information

This study focused on background information which involved; distribution by gender, climate change information sources and CSA awareness. The study involved both men and women. It showed that the responses were distributed diversely among gender. The percentage distribution of gender was that 60.5% were women while 39.5% were men. As **table 2** below, majority of the respondents were females at 60.5% while 39.5% were males. This shows that women were actively involved in agriculture in Masii ward as compared to men. This study is in line with previous studies which found that women are crucial in small scale farming in Africa because they comprise of a total of between 60-80% farmers (Collier, 2021). Other studies also found that if women are given equal access to amenities as men agriculture production can go up by 4% resulting in a reduction of world hunger to 17% (Collier, 2021).

**Table 2**

*Gender of Respondents*

| Gender | Frequency | Percent |
|---|---|---|
| Female | 170 | 60.5 |
| Male | 111 | 39.5 |
| **Total** | **281** | **100.0** |

Respondents were asked about their sources of information when it comes to climate change. Their responses showed that they got their climate change information from either farmer groups, extension officers, or the media. Their responses are shown in **table 3** below. Majority of the farmers (49.5%) got climate change information from extension officer, 47.7% from farmer groups, and 2.8% from the media that is radio/television. From the findings, the respondents disclosed that climate change information was crucial since it helped them to plan ahead in terms of when to plant since the planting season has to happen around the rainy period. Previous studies on climate change information have highlighted the crucial role climate change information plays to farmers as it ensures they make informed decisions on when to plant and harvest (Mullins et al., 2021).

**Table 3**

*Climate Change Information Sources*

| Sources of climate change information | Responses | |
|---|---|---|
| | N | Percent |
| Farmer groups | 134 | 47.7% |
| Extension officers | 139 | 49.5% |
| Media | 8 | 2.8% |
| **Total** | **281** | **100.0%** |

#### 4.1.1 CSA Awareness

The study found out that CSA in the country started as a five-year plan that was to end in 2020. However, when corona hit in 2020, it delayed the implementation of the project leading to its extension to the year 2023. However, before the CSA project came forth, extension officers were still working closely with the farmer groups among them being men, women, youth and people living with disabilities. These groups had benefitted the farmers greatly. It is through these farmer groups that the farmers practice table banking. Due to pooling of funds, the farmers got loans from SACCOs which they used to further themselves economically.

The study sought to find out how the respondents first got to hear about CSA. The responses disclosed that the firs got to hear about CSA either via farmer groups, extension officers, friends or the media. Their responses were as

follows; most of the respondents (89.3%) first heard about CSA from extension officers while the least (0.4 %) first heard about CSA from the media.

As shown in **table 4** below, majority of the respondents (89.3%) first heard about CSA (CSA) from the extension officer of their region. The responses from the respondents as well as the extension officer of Masii ward showed that the farmers consulted the officer and farm visits were also made. This was the reason for majority of them getting CSA updates from the extension officer. The study in addition found out that people in the region were sensitized about CSA through local barazas and also through the media such as radio. Through the barazas, the experts in CSA such as extension officer and KCSAP officials got to create awareness on CSA. Since it was practically impossible to teach every farmer the CSA methods, the lead farmer approach was used. Lead farmers would undergo training which took about three to four days. This training took place on their farms so that they get to practice what they are being taught in theory. These lead farmers being the group leaders of the groups. The lead farmers would then teach their members what they have been taught during their weekly meetings. The respondents reported that those meetings were participatory in nature and through that they got to learn a lot as pertaining to the agricultural practices to embrace for best results.

Studies in the past reveal that participatory approach is advantageous in that it puts into consideration the needs of the community in question (Koningstein & Azadegan, 2018).This was the case for the sensitization of CSA since the KCSAP officials actively engaged the locals. It was through the barazas that they aired their views and asked any questions they had with regard to CSA. Additionally, study by Braimoh et al. (2017) points out that through farmer groups, farmers and extension officers have a platform whereby they exchange ideas that will help them increase crop and livestock production. The KCSAP officials however sighted dishonesty from the respondents as one challenge they faced in the implementation of CSA. The officials further pointed out that some farmers in the region had not yet embraced CSA because they were ignorant in matters pertaining to CSA.

**Table 4**

*CSA Awareness*

| | | **Responses** | |
|---|---|---|---|
| | | **N** | **Percent** |
| How did you first hear about CSA | Media | 1 | 0.4% |
| | Friends | 2 | 0.7% |
| | Extension officers | 251 | 89.3% |
| | Farmer groups | 27 | 9.6% |
| **Total** | | **281** | **100.0%** |

### 4.2 Climate Smart Agriculture Activities Implemented in Masii Ward

The study sought to identify the CSA activities implemented in Masii ward. **Table 5** below outlines the CSA activities implemented in the ward.

**Table 5**

*CSA Activities*

| **CSA activities** | **N** | **Percent of cases** |
|---|---|---|
| Crop rotation | 4 | 1.4% |
| Mulching | 65 | 23.1% |
| Diversification of crop and livestock breed | 281 | 100.0% |
| Fertilizer use | 281 | 100.0% |
| Improved crop varieties | 281 | 100.0% |
| Use of terraces | 276 | 98.2% |
| Irrigation | 4 | 1.4% |
| Reduced tillage | 57 | 20.3% |
| Improved livestock breed | 280 | 99.6% |
| Others | 33 | 11.7% |

As shown in Table 5, the respondents indicated that they had incorporated various climate smart agricultural activities on their farms. These activities included; the use of quality seeds, use of fertilizers, diversification of crops

and livestock, terracing, conservation agriculture such as reduced tillage, improved livestock breed, irrigation and tree planting. The study found that out of a total population of 281 farmers, all farmers (100%) practiced diversification of crops and livestock, used fertilizers, and used improved crop varieties while 1.4% practiced irrigation and crop rotation. The study findings for each activity are discussed below.

### 4.2.1 Crop Rotation

The study found that 1.4% of the respondents practiced crop rotation as shown in **table 5**. The respondents added that crop rotation helped in controlling pests and weeds. This was confirmed by the extension officer who said that before the implementation of crop rotation, most farmers had complained about pests but after practicing crop rotation, the infestation of their crops by pests had reduced. The findings concur with other authors reporting that CSA strategies such as crop rotation play a role in increasing agricultural productivity (Shahzad et al., 2021). This is due to the fact that crops from the same family frequently have similar disease and insect problems. Hence practicing crop rotation using crops from several families reduces the accumulation of insects and diseases affecting that crop by disrupting the life cycle of these pests

### 4.2.2 Diversification of Crop and Livestock Breed

The study found that all respondents (100%) practiced diversification of crop and livestock breed as shown in **table 5** above. The respondents stated that they had been encouraged by the extension officer to diversify crop and livestock breed so as to increase productivity which in turn would increase their income source. The CSA project incorporated four value chains; pigeon peas, green grams, indigenous chicken and dairy as reported by the extension officer and the KCSAP officials. During the focus group discussion held on 18th November 2022, the key informants reported that when farmers practiced diversification of crop and livestock breed, they were able to accrue a variety of benefits as opposed to planting one type of crop or one type of livestock. These advantages included increased productivity whereby they sold the surplus thereby getting additional income. They further added that in cases whereby one type of crop did not do well, they were still able to harvest from the other crops planted. This study supports other studies by Wainaina (et al., 2017) which report that crop diversification has several benefits among them dietary diversification and income increase.

### 4.2.3 Fertilizer Use

As **table 5** above shows, 100% of the respondents used fertilizers on their farms. Data collected from focus group discussions administered to the key informants on 18/11/2022 indicated that fertilizers are essential to plant growth because they provide both macro and micro nutrients necessary for plant growth. The key informants further stated that the respondents used both organic and inorganic fertilizers in their shambas. They stated that in instances whereby the respondents were unable to buy the organic fertilizers due to financial constraints, they used the inorganic fertilizers instead. These inorganic fertilizers comprised of manure from animal droppings. In addition, respondents reported that to collect manure drop animal droppings, they set up compost pits whereby manure from livestock was stored. Other respondents for instance the dairy farmers revealed that they took their milk to Masii dairy whereby they bought fertilizers at wholesale price which is cheaper as compared to the retail price. According to literature from previous studies, collaborations between cooperatives and farmer groups are beneficial in that they enable farmers to have access to commodities like fertilizers and other farm inputs through the reduced prices (Braimoh et al., 2017).

### 4.2.4 Use of Improved Crop Varieties

The study reported that 100% of the respondents used improved crop varieties as indicated in **table 5** above. Study findings were that the plant-based value chains of the project that is pigeon peas and green grams were of improved varieties. The study findings as reported by the extension officer and the KCSAP officials were that the respondents planted mbaazi (II) type of pigeon peas which were drought resistant an adaptation crucial in Masii which is an arid and semi-arid region. Also, the variety of green grams used was of improved variety. The study findings from the focus group discussion with the KCSAP officials reported that the use of these improved crop variety resulted in better quality, more consistent production, and substantially higher yields. They further reported that KALRO; through carrying out research, was able to contribute to the agricultural sector by coming up with improved quality seeds and livestock genes. These study findings are in line with literature from other studies that indicate that one strategy CSA encourages is the use of improved crop varieties with the aim of increasing resilience by adapting to climate change thereby increasing agricultural productivity (Nyasimi et al., 2017).

### 4.2.5 Use of Terraces and Mulching

**Table 5** above indicates that 98.2% of the respondents used terraces in their farms whereas 23.1% practised mulching. Key informants revealed that mulching and building terraces were examples of CSA strategies for water management. The key informants reported that mulch is material such as leaves or compost that is spread over the existing soil. They added that by covering the soil with a layer of mulch, it blocks sunlight from reaching the weeds hence preventing their growth. Other benefits of mulching pointed out by the key informants was conserving soil moisture and improving soil fertility. They also reported that terraces on the other hand helped in reducing soil erosion and enhance its water holding capacity. Study by Rosenstock (et al., 2019) outlines terraces and mulching as examples of practices essential for water management in the agricultural sector.

### 4.2.6 Irrigation

The study found out that 1.4% of the respondents practiced irrigation as illustrated in **table5** above. The respondents that lived near the dams and those that practiced green-house farming reported that they used the irrigation system to water their crops. They stated that through irrigation their plants were able to get enough water necessary for growth. In addition, they reported that the proximity to the dam enabled them to fetch water for their animals with ease as compared to those that lived far away from the dams. Studies by Shahzad et al. (2021) state that irrigation is one of the CSA strategies that if implemented intensifies agricultural productivity by ensuring plants get enough water needed for proper growth.

### 4.2.7 Reduced Tillage

As **table 5** above shows, 20.3% of the respondents practiced reduced tillage. The respondents revealed that reduced tillage minimized disturbance to the soil through allowing crop residue to remain on the ground rather than being dumped or incorporated into the soil. The extension officer reported that the benefits experienced as a result of reduced tillage were minimizing the damage to the soil, reducing soil erosion by winds and reducing evapotranspiration of soil water thereby improving soil health. The extension officer also reported that before practicing reduced tillage, those farmers had reported that winds would blow away the top soil of their farms. However, after practicing reduced tillage, the crop residue on the farms would prevent soil erosion. This study is in line with other studies that discuss the importance of reduced tillage (D'Haene et al., 2009).

### 4.2.8 Improved Livestock Breed

The study findings were that 99.6% of the respondents had improved livestock breed as shown in **table 5** above. The extension officer and the KCSAP officials reported that the respondents were given weaners; an improved breed adapted to the arid region. Additionally, they reported that the improved livestock breed had increased productivity as compared to the local ones. For instance, for the farmers who had been given chicks, they laid eggs which they used for domestic use and sold the surplus eggs thereby getting additional income. The respondents reported that the productivity of the improved breed given was more compared to the local ones. Studies by Rosenstock (et al., 2019) illustrate how having improved livestock breed enables farmers increase livestock productivity since the improved breed has better traits as compared to the local breed.

### 4.2.9 Others (Tree planting)

As **table 5** above indicates, the respondents who practised tree planting were 11.7%. The respondents sighted providence of shade and reduction of soil erosion as the benefits they got from this practise. Other respondents added that they had planted fruit-bearing trees and once matured they would provide fruits for the family and also be a source of firewood to them. In addition, they reported that other trees would in the long run be a source of income since they would sell them as firewood or poles for building houses once they matured. According to literature, trees have a number of benefits including reducing soil erosion since the trees act as wind breakers thereby leading to retention of the top soil (Ghosh et al., 2016). Other studies outline the importance of tree planting as providing fruits and timber (Kallio, 2013). The findings of this study are in support of this literature.

The theory of change by Anderson (2005) outlines how the steps implemented by a project lead to the attainment of set objectives. Climate smart agriculture came about as a strategy of adaptation to the unpredictable climate changes which are being witnessed worldwide which would in turn lead to increase in agricultural produce. For the respondents, embracing CSA served as a way of enabling them to attain household security despite the harsh climate conditions. Literature evidence points to climate-smart agriculture as a promising strategy to feed the expanding global population in the face of climate change (Totin et al., 2018). To attain this, CSA focuses on three objectives namely; to increase agricultural productivity and farmers' incomes, to increase resilience by adapting to

climate change and lastly to reduce green-house gas emissions. It is crucial to note that strategies set for an arid area may not necessarily be the same as the ones for a highland region. Therefore, it is important for the stakeholders involved to come up with strategies that will best work for a region. That is why the World Bank in collaboration with the Ministry of Agriculture, Livestock and Fisheries laid out an action plan for each county before its implementation. That is why for Machakos County as a whole, the project centered on the four value chains so as to boost agriculture.

### 4.3 The Role of CSA Activities on Household Livelihood in Masii Ward

The study sought to assess the role of CSA activities on households' livelihood in Masii ward. The respondents were asked whether by embracing CSA they had witnessed any changes in their agricultural produce. They stated that embracing CSA had positively impacted their households' livelihood in a variety of ways. The benefits the respondents stated were; surplus income and produce, reduction in soil erosion through tree planting, availability of food, employment, improved animal and plant productivity and increased awareness on agricultural practices. These benefits are illustrated in **table 6** below.

**Table 6**

*The Role of CSA Activities on Household Livelihood*

| **Benefits of CSA** | **N** | **Percent of cases** |
|---|---|---|
| Surplus produce and income | 280 | 99.6% |
| Reduction in soil erosion through tree planting | 6 | 2.1% |
| Availability of food | 280 | 99.6% |
| Employment | 122 | 43.4% |
| Improved animal and plant productivity | 278 | 98.9% |
| Increased awareness on agricultural practises | 281 | 100.0% |

As illustrated in **table 6** above, CSA had brought various advantages to the farmers. To 99.6%, to 99.6% availability of food even amidst the adverse climatic conditions, 43.4% got employment opportunities. In addition, through CSA, 98.9% saw improved animal and plant productivity. Finally, 100% stated that CSA increased their awareness on agricultural practices. These advantages are further discussed below.

#### 4.3.1 Surplus Produce and Income

The study findings were that 99.6% of the respondents reported a surplus of produce and income due to embracing CSA as shown in **table 6** above. The respondents reported that due to diversifying their crop and livestock produce, they were able to increase their harvest as compared to previous years. Some further stated that from their last harvest of pigeon peas, they had been able to harvest a surplus of between 2-3 bags; an achievement they had not attained before. They also revealed that the additional produce was sold resulting in additional income. The respondents reported that they used the additional income generated to carter for other necessities such as paying school fees for their children, buying the foods they didn't have and boosting their businesses. This enabled them afford to provide a variety of foods to their families. Consequently, making them food secure in the midst of the adverse climate conditions they were facing. However, they stated that rainfall had not been favorable to them for three seasons, hence they did not harvest as much as they had expected they would. These study findings are in line with study by (Wainaina et al., 2017) which state that climate-smart agriculture improves food security by increasing agricultural income through more yields or by freeing up labor for alternate economic pursuits.

#### 4.3.2 Reduction in Soil Erosion through Tree Planting

As **table 6** above shows, 2.1% of the respondents planted trees. The respondents stated provision of shade and reduction of soil erosion, source of firewood and fruits as some of the benefits they got from tree planting. The study likewise revealed that Masii being an arid and semi-arid region, shade from trees enabled the respondents to bask under the trees and experience the gentle breeze brought about by the blowing winds; bringing about a relaxing effect. According to other literature, planting trees around the compound reduces soil erosion since the trees act as wind breakers thereby leading to retention of the top soil (Ghosh *et al*., 2016). The findings of this study corroborate this literature.

### 4.3.3 Availability of Food

Food availability was one of the benefits of CSA adoption as reported by the study at 99.6% as shown in **table 6** above. The respondents reported that due to planting a variety of foods and diversifying their livestock, they got an increase in both animal and livestock yield making food more available to them. The extension officer reported that various farmers had reported an increase in produce as a result of embracing CSA as compared to before when they would harvest close to nothing because of drought. Some respondents reported that they had granaries whereby they stored dried surplus harvest of pigeon peas and green grams. Literature points out that CSA methods are targeted at maintaining both sustainability and agricultural intensification, which are both important for increasing production (Karlsson et al., 2018).

### 4.3.4 Employment

As **table 6** above indicates, 43.4% of the respondents reported that CSA had brought about employment opportunities to them. The KCSAP officials reported that the lead farmers were trained by KCSAP officials and then later passed down the information learnt to other farmers. These lead farmers were paid for training they gave to the other farmers hence CSA enabled them to get additional income which they had not planned for. It is also through these interactions that the farmers broadened their networks and some even got other contract jobs with other non-governmental organizations in their regions. This study concurs with an article by the Consultative Group on International Agricultural Research (CGIAR) reports on how farmer trainings have helped farmers supplement their income and at the same time increased their awareness on various agricultural practices (CGIAR, 2019).

### 4.3.5 Increased Awareness on Agricultural Practices and Improved Animal and Plant Productivity

The study findings on benefits of CSA were that 100% of the respondents reported increased awareness on agricultural practices while 98.9% reported improved animal and plant productivity as illustrated in **table 6** above. The respondents reported that the extension officer through the lead farmers educated them on the best farming practices. They further added that implementing these practices led to an increase animal and plant yield both in quality and quantity. The respondents also revealed that CSA had empowered them in that they are aware on what and how to plant for best results. From the trainings they had undergone, they were able to identify the mistakes they had been doing and the measures they had to implement for optimum results. The respondents demonstrated their expertise by showing the researcher their farms and explaining the importance of various farming measures they had implemented such as spacing between crops and crop diversification. Moreover, the respondents stated that due to the benefits they had got from practicing CSA, they were more encouraged to keep embracing CSA since for some of them; agriculture was their major source of livelihood. The achievements of CSA in Masii region will add to the success stories of CSA across the world. Some of the success stories of CSA are found in reports given by the Food and Agriculture Organization (FAO, 2010). In addition, from the discussions, the researcher learnt through CSA, five dams had already been constructed in Machakos County saving some people time and effort used walking long distances in search of water.

The theory of change by Anderson (2005) outlines that, for the attainment of a certain goal, an action plan is necessary. For our case study, the aim evaluating status of CSA on household livelihood. Form the discussions above about the benefits experienced as a result of CSA adoption, it suffices that the goal of attaining household sustainability despite harsh climate conditions was obtained. The respondents were able to harvest enough produce for domestic use and sold surplus for additional income.

### 4.4 Response on CSA impact on Household Livelihood

On being asked on whether CSA had a positive impact on their household livelihood, 84% of the respondents strongly agreed that it had, 13.9% agreed that it had a positive impact on their livelihood and finally 2.1% neither agreed nor disagreed on the effect of CSA on household livelihood. The study found that the 2.1 % that neither agreed nor disagreed based their answer on the unfavorable weather conditions experienced during that period making their plant and animal productivity not to be higher as they had hoped. The results are outlined in **table 7** below.

**Table 7**
*CSA's Impact on Household Livelihood*

| Response | Frequency | Percent |
|---|---|---|
| Strongly agree | 236 | 84.0 |
| Agree | 39 | 13.9 |
| Neither agree or disagree | 6 | 2.1 |
| Disagree | 0 | 0.0 |
| Total | 281 | 100.0 |

## V. CONCLUSIONS & RECOMMENDATIONS

### 5.1 Conclusions

Farmers have indeed adopted CSA strategies, as evidenced by the CSA activities implemented in the region discussed in the first objective. Climate-smart agriculture has truly had a positive impact on household livelihood in terms of enabling the farmers to provide for their essential needs, maintain nutritional uptake, and get surplus income to provide for their other needs. Households are able to afford a balanced diet due to increased plant and animal productivity and the availability of surplus income. This surplus income caters for other needs such as proper health care, proper housing, and practicing off-farm activities. If climate-smart agriculture is embraced by more people, it will for sure help in alleviating hunger, especially in these times where climate change is a main issue due to its unpredictability. In the long run, the whole community will have benefited from the improved agricultural practices. Besides, if the CSA project is consistent, it will achieve its three pillars, which are adaptation, resilience, and mitigation of greenhouse gases.

### 5.2 Recommendation for practice

Sensitization on climate-smart agriculture should continue so as to create more awareness about it and enable more farmers to embrace it. This can be done through village barazas and also local radio stations so as to reach more people. Youth should be encouraged by the government to venture more into agriculture since the agricultural benefits accrued can be a source of livelihood for the unemployed. This can be made possible by agricultural experts creating awareness about agriculture through holding talks and seminars, which can be shared via social media platforms that the youth frequently visit. Additionally, the success stories of the youth already reaping from agriculture can be shared to serve as motivation for others that indeed it is possible to make a living from agriculture.

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