Effects of Climate Smart Agriculture Technologies on Household Food Security in Makueni County, Kenya

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Abstract: Food insecurity is a concern for households and government. It destabilizes social, economic and political wellbeing. Despite Kenya's government efforts in provision of incentives like climate smart subsidies to address food insecurity, Makueni County still experiences food deficit. This article focuses on effects of climate smart agriculture technologies on household food security. Findings revealed improvement in food security as 21.8 per cent households were food secured compared to 2 percent in 2012, attributing to existence of climate smart fund. From findings, access to farm input and practising Agroforestry increases crop yields and thus food availability, accessibility and affordability.

Keywords: *Cropland Practices, conventional farming, climate smart agriculture technologies, food security*

Introduction

There is global demand for agriculture to produce more on the same amount of land while adapting to a changing climate extreme weather events such as drought and floods (Steenwerth *et al*., 2014). A study by Nyongesa *et al*., (2017) cited climate change and vulnerability as one of the biggest environmental, social and economic challenges currently facing the World as well as undermining the drive for sustainable development, particularly in sub Saharan Africa. Further, the same study depicted a change in precipitation pattern that was consistent with projection that Kenya's vulnerable ASALs would experience an increase in the frequency and severity of droughts and significant declines in rainfall and river flows due to climate change and vulnerability necessitating adoption of CSA. FAO, (2014) found that CSA increases crop yields, enhance carbon content in soils and maintain soil moisture. In this regard, CSA contributes to the achievement of sustainable development goals by integrating the three dimensions of sustainable development (economic, social and environmental) to address food security and climate challenges FAO, (2013).

Across Africa, farmers are embracing "climate-smart" innovations against challenges of more frequent, intense and longer droughts, and floods which threaten sustainable development Nyasimi *et al.,* (2014). In 2011 more than 12.5 million people were affected by the prolonged drought and the result was catastrophic famine and hunger in the Horn of Africa. In response, Africa has put in place many initiatives on CSA technologies with capacity to increase agricultural productivity and build resilience. Despite these efforts, they remain unrecognized at the continental, regional and even national level (World Bank, 2015).

Further impact of the drought was felt in 2012 in Kenya where over 10 million people suffered from chronic food insecurity and poor nutrition, while 7.5 million people live in extreme poverty (Republic of Kenya, 2012). The country has continued to experience four consecutive rain seasons failures from the long rains of 2016 with population at risk increasing from 1.2 Million people in July 2016, to 2.5 Million people in February 2017 and 3.5 Million people in September 2017 (Republic of Kenya, 2014). This led to extreme drought situation in the 23 ASAL Counties and subsequent declaration of drought as a national disaster by the President in February 2017. In regard to this situation, Kenya is geared to transform its agriculture sector in order to meet the food demand for its growing population through sustainable land and water management practices (World Bank, 2015). The government efforts according to the World Bank, include scaling up of CSA technologies, practices and innovations through an institutional coordination approach as follows: the Constitution of Kenya devolves key agricultural sub-sectors to county government for timely agricultural decision making that accelerate the implementation of policies and incentivize CSA adoption; *Kenya Vision 2030* target agricultural investment in key areas such as productivity of agricultural enterprise, expansion of irrigated land for agriculture, improve market access and supply chains; the *Agricultural Sector Development Strategy 2010-2020* under the Ministry of Agriculture, Livestock and Fisheries focuses on transforming smallholder agriculture from low-productivity subsistence activities to a more innovative agribusiness.

Despite these different frameworks, policies and strategies developed over the years, coordination is critical for successful implementation of CSA interventions. In this regard, the government developed the *Kenya Climate Smart Agricultural Program 2015-2030 Framework* to provide effective coordination of CSA interventions in the country. Kenya and the World over is searching for technological and environmental solutions that can combat the resultant food deficit, change of eating habits and negative attitude towards new appropriate technological strategies (World Bank, 2015). In line with Vision 2030 and Agricultural

Sector Development Strategy 2010-2020 both have objectives of transforming agriculture into modern and commercial viable sector achieving an average GDP growth rate of 10 percent per year up to 2030 in Kenya.

Effect of Climate Smart Agriculture Cropland Practices on Crop Yield and Income

Wekesa *et al.,* (2018) while studying the effect of CSA technologies on household food security in smallholder production systems in Teso North subcounty, Busia County of Kenya, grouped the climate smart strategies into four categories. The groups were as follows: Crop management practices (use of improved crop varieties, efficient use of inorganic fertilizers, changing planting dates, use of legumes in crop rotation and cover crops); general field management practices (use of terraces, planting trees on crop land, use of live barriers); farm risk reduction practices (diversified crops, irrigation); and soil conservation practices (planting food crop on tree land, use of mulching).

Neufeldt *et al.,* (2011) while citing Norton-Griffith, (2008) showed that net returns- crop yields and incomes on adjudicated land was approximately three times higher than on un adjudicated land which has less secure tenure. In this regard, household investments in crop diversity, agroforestry and soil conservation were all significantly higher on more secured land tenure with resultant higher crop yields and income.

The researchers quantified the effect of using the categories of climate smart strategies and found that farmers who adopted climate smart strategies that included farm risk reduction practices- *diversified crops, irrigation*, has a positive impact on the welfare of farmers. This implied that farmers need to manage their farm risks to be assured of improved food security in the uncertain events of climate change. Further, farmers who adopted all categories of climate smart strategies (Crop management, general field management, farm risk reduction and soil conservation practices) were more food secure compared to their counterparts who did not use CSA technologies and had the greatest overall effect of 30.14 score on the welfare of farmers estimated using household food consumption score (Wekesa *et al.,* 2018).

Impact of Soil and Water Management Techniques on Crop Yield and Income

Branca *et al.,* (2011) while studying on promoting food security through adoption of soil and water management technologies found that there was increasing crop yields in low fertility and drier areas of sub Saharan Africa. For example, capturing rainwater where it falls, retention of soil moisture and increasing water productivity through irrigation can enhance overall crop yield. However, only 15-30 percent of rainfall is available for crop production during high runoff and low infiltration rates and thus adoption of soil and water management technologies such as water harvesting technologies, irrigation infrastructure and conservation agriculture can reverse this trend.

In line with observation made by Branca *et al.,* (2011), Tshuma *et al.,* (2012) stated that any farmer or agricultural system with access to sufficient inputs, knowledge and skills can produce large amount food, and thus food become available at household level. For instance, introduction of conservation agriculture (CA) by an NGO in Mangwe, Zimbabwe with provision of inputs and trainings, farmers interviewed confirmed that they harvested more grain on CA cultivated land than conventional farming despite being labour intensive. The findings on the potential of CA to improve yields and most likely food security too, were consistent with those of earlier studies conducted in different parts of the world. For example, Mazvimavi (2011) in Tshuma *et al.,* (2012) stated that CA plots produced higher yields than conventional plots as depicted by the harvest of the 2008/2009 season where on average maize yielded 1546 kg/ha on CA compared to 970 kg/ha on conventional farming thereby improving food availability. However, the impact of CA on yields as is currently practiced in Zimbabwe is still minimal.

Another study on whether more innovative farmers are more food secure, or whether food insecure farmers simply cannot invest in new technologies was analysed in a 2011 study of 700 randomly chosen farm households across five sites in Ethiopia, Kenya, Tanzania and Uganda by Dawnson *et al.,* (2013) on practicing agroforestry. The findings show that both innovation (CSA) and food security significantly influence each other. In this case, Neufeldt *et al.,* (2011) argued that if food security is dependent to some extent on the ability or willingness to innovate it is important to look at the innovations that are already being implemented and identify the institutional arrangements and technical, management, capital, financing and market-relevant factors which allow for successful up-scaling. On the other hand, the same researchers affirmed that if food insecure farmers are unable to innovate (adopt CSA) then safety nets such as cash credit and insurance will be critical before they can make significant changes to their farming practices.

The vulnerability models

The multi-dimensional nature of the vulnerability model as posted by Roxana *et al* (2013) investigates five dimensions of assessment in household vulnerability in Makueni County. First, the physical/functional dimension which relates to the disposition of a structure, infrastructure or service to be damaged due to the occurrence of a harmful event associated with drought; second was the economic dimension which relates to economic stability of a household endangered by a loss of production, decrease of income, or consumption of food due to the occurrence of a protracted drought. The third was the social dimension that relates with the presence of human beings, individuals or communities, and their capacities to cope with, resist and recover from impacts of hazards-climate change and drought. The fourth assessment was the environmental dimensions inferring interrelation between different ecosystems and their ability to cope with and recover from impacts of hazards over time and space. Lastly, the political/institutional dimension which were the political or institutional actions such as livelihood diversification, risk mitigation strategies- insurance, credit markets, social safety net programs, government and donor-funded projects and agricultural extension or regulation control that determines different coping capacities and exposure to hazards and associated impacts.

The Bohle's vulnerability conceptual framework further illustrate the interaction between the interventions (CSA technologies) expected to increase household productivity and incomes as well as enhance resilience to impacts of hazards- climate change, drought and floods. Bohle's Vulnerability Conceptual Framework is a combination of famine and food insecurity vulnerability together with climate change and variability vulnerability (Shitangsu, 2013). The former explains vulnerability to famine in the absence of shortage of food or production failures as well as describing vulnerability as a failure of entitlements and shortage of capabilities according to Bohle *et al* (1993) as used in Shitangsu, (2013).

According to Bohle, (2001) vulnerability to food insecurity as well as climate change and variability has external and internal perspectives thereby referred to as double structure of vulnerability model. The external side of the model is related to the exposure of household to risks and shocks and is influenced by political economy approaches such as social inequities and disproportionate division of assets together with human ecology perspective which includes population dynamics and environmental management capacities. The Entitlement Perspective relates vulnerability to incapacity of household to obtain or manage assets through legal and customary rights to exercise command over food and other necessities of life (Mendes et *al.*, 2012). This complements the foregoing two models as advanced by Roxana *et al* (2013) and Bohle (2001) in strengthening and supporting the security of land tenure perspective which plays critical contribution to adoption and investment of climate smart agriculture technologies.

Methods and Materials

Study Area

The study was conducted in Makueni County in its three Agricultural Ecological Zones (AEZ) –Upper (1), Middle (2) and Lower (3) of the four (4) constituencies as follows: Mbooni-(Upper Zone-1), Kaiti/Kilungu (Upper and Middle Zones-1/2), Makueni / Kathonzweni (Middle and Lower Zones-2/3), and Kibwezi West/Makindu (Lower Zone-3). The County is characterized by a rapid growing population, water scarcity, falling food production and low resilience to climate change and variability (Republic of Kenya, 2014). The County has a total population of 883,671 people (2009 census) with an annual growth rate of 2.4%, which is projected to 922,183 in 2012 and further projected at 1,002,979 in 2018. This consists of 488,378 males and 514,601 females, out which 90% of the population settles in the rural areas (MCIDP, 2018-2022, Republic of Kenya, 2013; CBS, 2002).

Research design

Researcher used descriptive and inferential research design that employed cross sectional approach to examine the contribution of climate smart agriculture on household food security in Makueni County since the design facilitates a detailed description of the problem and inferences made in the study population as it "involves a close analysis of a situation at one particular point in time to give a snap shot result" (Neville, 2007).

Sample size

The sample size was drawn from a list of 784 villages obtained from the Kenya National Bureau of Statistics (KNBS) with projected population of 1,002,979 in Makueni County. A sample size of 32 villages was randomly drawn from the population frame out of which 400 households participated in the study. Key informants were representatives from the Ministry of Agriculture, Fisheries and Livestock; Kenya Agricultural and Livestock Research Organization (KALRO), National Drought Management Authority (NDMA) and Non-governmental organizations.

Data collection

Qualitative and qualitative data was collected through a household survey questionnaire, key informant interviews and focus group discussion were administered personally by the researcher and occasionally with the help of research assistants. Observation was used to corroborate information collected using the three data instruments. Data collection instruments were developed after analysis of similar studies through literature review, deliberations with practitioners in this field. Household questionnaire had a five point Likert scale designed to assess effects of climate smart agriculture technologies on household food security in Makueni County. A focused group discussion guide was used in selected households to explore issues related to food security and climate smart agriculture. Key Informant Interviews (KII) guide was developed and administered to experts from various organizations that formed part of respondents. Obtained data was used to triangulate questionnaire survey feedback given that experts were purposively chosen to participate as KII. All instruments were pre-tested during piloting and adjustments made accordingly before its final administration. Piloting was mainly used to validate the tools.

Data analysis

Both quantitative and qualitative approaches were used for data analysis. Quantitative data from the questionnaire were coded and entered into the computer for computation of descriptive and inferential statistics. Statistical Package for Social Sciences (SPSS) was used to analyze collected data while qualitative data from key informants were manually processed and presented verbatim.

Results and discussion

Assessment on the Status of Household Food Security

Researcher sought to assess overall household status of food security. Responses from respondents were given on figure 1.

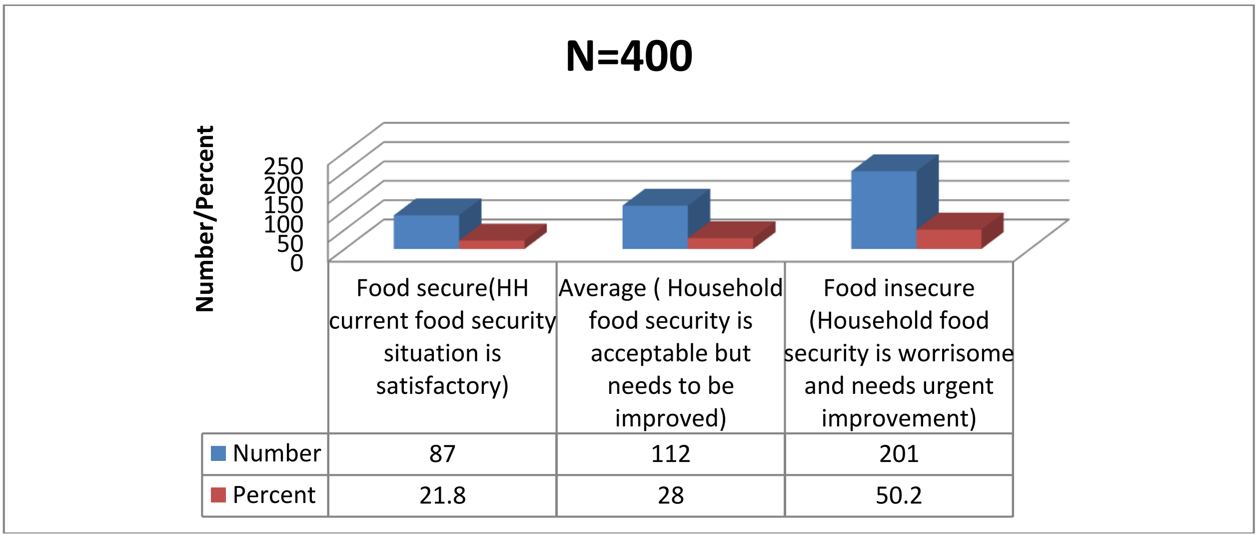

Figure 1 Household Assessment on the Status of Food Security

Figure 1 shows that majority of households at 50.2 per cent feel that they were "food insecure" at the time of data collection which agrees with another finding in this study that majority of households (59%) did skip or ate fewer meals in a day at different levels because there was no enough food while 21.8 per cent of households were "food secure" in all the 24 months. This feedback is corroborated by Key informants and focus group discussion members who mentioned that despite several programmes to make Makueni food secure, the results have not yet been fully realized. Focus group discussion members reported that households feel they are food insecure due to the number of meals per day that households prepare and the level of living standards.

Key informant interviewees attributed the high score on food insecurity to poor rains and pests that attack food crops. Focus group discussion member in Kibwezi said "If we had regular rain we would not be begging for food from organizations and government. It is not dignifying to beg for food every year. National government and county government should help us with extension services which will educate us" However, there has been significant improvement on the status of food security as households responded to be "food secure" at 21.8 per cent in Makueni County as a result of investments on CSA technologies compared to a Baseline Household Survey in Makueni County conducted by Mwangangi *et al.*, (2012) who indicated that only 2 percent of households are "food secure" all year long and 97 percent of households struggle to get enough food to feed their family for more than 2 months out of a year. The improved household food security is attributed to increased crop yields and incomes from sales as result of combined investment in CSA diversified crop practices and high capital-intensive technologies that reduces the risk of harvest failure in times of drought and/or extreme climatic events according to Tshuma *et al.*, (2012). This implies that the accessibility and availability dimensions of food security are ultimately improved resulting in increased household food security in Makueni County.

Effects of CSA on household food security

This objective sought to find out how climate smart agriculture (CSA) technologies affects household food security in Makueni County. The researcher sought to find out the effect of the following CSA technologies namely farm inputs, credit access, agroforestry practices, land tenure and size, irrigation technology, agricultural extension services, conservation agriculture and water harvesting practice on household food security. Respondents were further asked to indicate their assessment of various statements in relation to household food security. Information from households is presented on Table 1.

Table 1: Effects of CSA on Household Food Security

Variable	Score	Frequency	Percent
	Strongly disagree	21	5.3
Access to farm input significantly increased crop yields	Disagree	12	3.0
	Neutral	20	5.0

	Agree	124	31.0
	Strongly agree	223	55.8
	Total	**400**	**100**
Access to farm input has not changed production	strongly disagree	189	47.3
	Disagree	58	14.5
	Neutral	26	6.5
	Agree	38	9.5
	Strongly agree	89	22.3
	Total	**400**	**100**
Access to credit significantly increased crop production/yield	Strongly disagree	150	37.5
	Disagree	24	6.0
	Neutral	77	19.3
	Agree	89	22.3
	Strongly agree	60	15.0
	Total	**400**	**100**
Access to credit has not changed production	Strongly disagree	180	45.0
	Disagree	50	12.5
	Neutral	68	17.0
	Agree	26	6.5
	strongly agree	76	19.0
	Total	**400**	**100**
Agro forestry practice brought additional income	Strongly disagree	25	6.3
	Disagree	12	3.0
	Neutral	41	10.3
	Agree	115	28.8
	Strongly agree	207	51.8
	Total	**400**	**100**
Agro forestry has significantly enhanced crop production/yield	Strongly disagree	26	6.9
	Disagree	18	4.5
	Neutral	58	14.5
	Agree	94	23.5
	Strongly agree	204	51.0
	Total	**400**	**100**

N=400

Results from table 1 showed that overwhelming majority of respondents at 86.8% agrees that access to farm input significantly increases crop yields while another proportion at 61.8% disagree that access to farm input doesn't change farm production. This shows that farm input access is favored by households who want to increase crop yields and farm income.

These findings are corroborated by key informants and focus group discussion members who opined that access to farm inputs increased their farm production. One member of focus group in Mbooni said

> "I have been able to improve my farm produce because I got farm inputs which I could use on my own. If other households are able to access farm inputs like myself then they will surely improve their production".

This result is in line with observation made by Branca *et al.*, (2011) and Tshuma *et al.*, (2012) that any farmer or agricultural system with access to sufficient inputs, knowledge and skill can produce large amount of food, and thus enhancing food availability at household level. The high yields is attributed to farmers when given access to credit, it will enable them to acquire more technologies which might be expensive to purchase. This agrees with the findings of Amao and Ayantoye, (2015) in Ojoko et al., (2017) who opined that access to credit in the form of loanable funds can be used to expand production through the purchase and use of modern improved inputs. However Wekesa *et l.*, (2018) observed a negative influence of credit access to

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usage of improved crop varieties and agroforestry suggesting that these farmers diverted credit to fund non-farming expenses like school fees and medical.

Regarding credit access, the study showed that very small minority of households at 43.5% disagreed that credit access increases crop yields and production significantly. 19% of household representatives scored neutral which is attributed to the fact that 78.5% did not access credit during the period under review. Also 57.5% of respondents disagree that access to credit does not change household production in any way. Further discussion with key informants showed that majority of respondents thought that credit access alone did not increase crop yield and production automatically. A key informant member said

> "Even if we access credit we shall not improve our production if we put that credit to non-agricultural and unproductive use such as paying school fees and paying dowry and debts".

The results revealed that households think credit access as an incentive and not necessarily as the automatic guarantee for higher yields and production. In this regard, most CA implementers in Zambia use hybrid seeds and fertilizer on credit, allowing them to use more CA inputs and increase their chances of successfully practicing CA. Additionally, the credit accessed was likely and potentially used for unintended purposes in the household other than agriculture which is agreed by Wekesa *et al.*, (2018).

On agroforestry, majority of households at 80.5% agreed that agroforestry has enabled them to earn some additional income for their household food consumption whereas 74.5% of households agreed that agroforestry has significantly enhanced their crop production/yields. Agroforestry is recognized as an important component in climate-smart agriculture for its potential to stabilize crop yields in drought conditions, in addition to adaptation and mitigation roles. For example, in Zambia, agroforestry practice increased maize yield from 2.8 tons/ha to 7 tons/ha according to Kipkoech *et al.*, (2015). According to Dawson *et al.*, (2013) the increased yields is attributed to its potential for the diversification of crop production, planting of trees as green fertilizers and nutritionally balanced fruits as well as fuel wood. In contrary Dawson *et al.*, (2013) argued that the planting of tree commodity crops can result in a risk that food crop will be displaced from farmland and FAO & IFAD, (2012) agrees that often agroforestry is viewed specifically within agricultural production-based strategies designed to improve nutrition.

Table 2: Effects of CSA on Household Food Security

Variable	**Score**	**Frequency**	**Percent**
Land tenure system improved income and consumption	Strongly disagree	39	9.8
	Disagree	19	4.8
	Neutral	10	2.5
	Agree	128	32.0
	Strongly agree	204	51.0
	Total	**400**	**100**
Land tenure system has improved crop production and yields	Strongly disagree	34	8.5
	Disagree	19	4.8
	Disagree	16	4.0
	Agree	116	29.0
	Strongly agree	215	53.8
	Total	**400**	**100**
Farm size increased income and food consumption	Strongly disagree	25	6.3
	Disagree	26	6.5
	Neutral	48	12.0
	Agree	122	30.5
	Strongly agree	179	44.8
	Total	**400**	**100**

N=400

Table 2: presents results on land tenure systems and farm size practices. Under land tenure, the study depicts that majority of households (83%) think favorably of the prevailing land tenure in Makueni County where respondents said that it has enabled them to earn some additional income for their household food consumption. In addition, the study indicates that majority of households at 82.8% agreed that existing land tenure has significantly enhanced their crop production/yields. This can be attributed to security of land tenure that incentivize promotion of investing in CSA practices and technologies as well as being an

enabler to access credit from financial service providers. This agrees with the findings of Neufeldt *et al.*, (2011) who opined that crop yields and incomes on adjudicated land (land with title as security of tenure) was three times higher than on un adjudicated land which has less secure tenure.

The researcher also sought to know what households think of farm size and how it relates to food security. Majority of respondents at 75.3% are satisfied with their farm land size currently in use which they reported to have increased their income for household food consumption while similar proportion (76%) agree that their current farm land size has significantly enhanced their crop production/yields. This finding is attributed to response whether household's practice intensive farming and majority of households (64.8 per cent) were engaged in intensive agriculture on their land whereas more than half of respondents at 91 per cent used less than 3 acres of land for cropland food production during the period under study. This is consistent with study by Lewin and Fisher, (2010) who revealed that an increase of 0.25 ha per capita of cultivated land would increase the likelihood of food insecurity by 22, 24, and 27 per cent in the north, central and south regions of Malawi, respectively.

Table 3: Effects of CSA on Household Food Security

Variable	Score	Frequency	Percent
	Strongly disagree	61	15.3
	Disagree	26	6.5
Using irrigation increases income and food consumption	Neutral	59	14.8
	Agree	115	28.8
	Strongly Agree	139	34.8
	Total	**400**	**100**
	strongly disagree	61	15.3
Use of irrigation has significantly enhanced crop yield compared to rain fed agriculture	disagree	26	6.5
	Neutral	59	14.8
	Agree	115	28.8
	Strongly Agree	139	34.8
	Total	**400**	**100**
	Strongly disagree	97	24.3
Use of harvested water increased crop yields	Disagree	18	4.5
	Neutral	61	15.3
	Agree	138	34.5

	Strongly Agree	86	21.5
	Total	**400**	**100**
Water harvesting increased yields that increased incomes	Strongly disagree	105	26.3
	Disagree	27	6.8
	Neutral	70	17.5
	Agree	113	28.3
	Strongly Agree	85	21.3
	Total	**400**	**100**
Agricultural extension services increases yields and incomes	strongly disagree	33	83.0
	Disagree	12	3.0
	Neutral	30	7.5
	Agree	125	31.3
	strongly agree	200	50.0
	Total	400	100.0
Extension services have become more expensive today	strongly disagree	143	35.8
	Disagree	31	7.8
	Neutral	29	7.3
	Agree	82	20.5
	Strongly Agree	115	28.8
	Total	400	100

N=400

Table 3 presents results for irrigation and water harvesting techniques. According to respondents, majority of households at 63.5 % accepted that the use of irrigation had enabled them to earn some additional income for their household food consumption whilst similar proportion at 63.5% agreed that use of irrigation has significantly enhanced their crop yields compared to rain fed agriculture. This finding is in consistent with the study of McCarthy & Brubaker (2014), who stated that increased use of irrigation leads to food security and adaptation benefits by increasing crop yields and decreasing variability of yields. Similarly, their study revealed that supplementary irrigation maximizes productivity in a shortened growing season due to delayed onset of rains. In this regard, new irrigation projects with high investment cost may ultimately prove to be unsustainable in the long-run due to climate changes in precipitation and evaporation rate, requiring in-depth feasibility studies to avoid failures of collective action in operation and maintenance.

The study finding showed that most households at 81.3% agreed that food production was higher in yields than previously as a result of use of agricultural extension services while 49.3% agree that agricultural extension services have become more expensive today than in the past. This finding is in accordance with National Agricultural Sector Extension Policy (NASEP, 2012) that indicated extension services through sharing knowledge, technologies and agricultural information enhances promotion of household food security, improving incomes and reducing poverty. In the contrast, Kipkurgat *et al.*, (2015) found little information on the impact of decline in extension services on food security. In this regard, this finding attributes to cost of extension services to the households and indeed Abdi & Worth *et al.*, (2011) agreed that commercializing and privatizing public extension services renders it very expensive and compromising public interest.

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On water harvesting, the study found out that 56% of the households agree that water harvesting use has increased crop yields while a lower proportion of respondents at 49.5% said that water harvesting had significantly enhanced yields which increased household incomes. The low score of respondents who agreed that water harvesting practices increases yields and incomes was attributed to few respondents who practice water harvesting for agricultural production (21.5%) in Makueni County. Additionally, this finding depicted the trade off in the water use as majority used for domestic as well as the cost involved in the use of other harvesting techniques.

This finding was attested by Mwangangi *et al.,* (2012) who revealed that only 9 per cent of the household were practicing irrigation most of which is under kitchen garden and 17 per cent had tanks for water harvesting in Makueni County. However, there was significant improvement in the adoption of the water harvesting technology as depicted by this finding where households practicing agricultural production using rooftop water harvesting increased from 9 per cent to 21.5 per cent. As a result, increased crop yields and incomes, is seen to increase food security. This is consistent with findings of Branca *et al.*, (2011) that water harvesting in Senegal changes the yields of millet from 75 per cent to 195 per cent.

In line with Sendai Framework for Disaster Risk Reduction (UNISDR, 2018), Climate Smart Agriculture (CSA), reduces vulnerability of households' food insecurity caused by hazards of drought, floods and climate change through enhanced adaptive capacity to change in climate, increased resilience to climate change and agricultural productivity as well as promoting policies intervention especially that aim at the adoption of CSA technologies. Additionally, CSA addresses disaster risk with respect to vulnerability of households through promoting climate smart subsidies, access to credit, and creation of market and extension services. This is in agreement with a study of Kipkoech *et al.,* (2015) who stated that elements of CSA relate to improving resilience through the adoption of sustainable agricultural land management such as agroforestry, water-use efficiency, drought tolerant varieties and risk avoidance. This study contributes to attainment of sustainable development goal number 2 of reducing hunger and to realization of the Sendai framework priority for Action 3 that underpins investing in DRR for enhanced resilience to hazards.

The researcher sought to establish households that practice conservation agriculture and to assess whether conservation agriculture increases yields and incomes as well as whether is more productive than the conventional farming (normal land preparation practices -ploughing). Households were asked to evaluate and gave their responses on table 4.

Table 4: Effects of Conservation Agriculture and Conventional Farming

Description	**Score**	**Frequency**	**Percent**
Did you practice Conservation Agriculture (CA) in the years 2017/2018?	Yes	176	44
	No	224	56
	Total	**400**	**100**
CA is more productive in yields and incomes	strongly disagree	131	32.8
	Disagree	26	6.5
	Neutral	26	6.5
	Agree	106	26.5
	Strongly Agree	111	27.8
	Total	**400**	**100.0**
CA meets my food requirements better than conventional farming	strongly disagree	121	30.3
	Disagree	33	8.3

Neutral	41	10.3
Agree	90	22.5
Strongly Agree	115	28.8
Total	**400**	**100.0**

N=400
Table 4 showed that few households (44%) practice conservation agriculture (CA) however majority of respondents (54.3%) accept that CA is more productive in yields and incomes. Further, the study revealed that majority of households (51.3%) agreed that practicing CA enabled them to meet their food requirements better than conventional farming. . This result is in line with that of Tshuma *et al.,* (2012) in Mangwe, Zimbabwe where 84 respondents' farmers were asked to make comparison in terms of crop yields of conservation agriculture (CA) and conventional farming (CF). In this case all respondents indicated that CA had a better yield output compared to CF. Study by Malachy *et al,* (2010) attribute this finding to CA realizing social and financial capital through building partnership between groups within community to access credit and also counteract the labour intensity of CA especially for weeding.

Another argument for higher crop yields from CA was that CF waits for the first rains of the season to soften the soil before preparations or ploughing for sowing. This negatively affect households without tractors or oxen plough resulting in waiting for several weeks before getting the farm machinery, and thus delayed land preparations and planting. For instance, a study in Zambia found that this delay in planting reduced harvest with 1.5 per cent of potential maize yields lost for each day delayed after the first opportunity to plant (Mazvimavi, 2011). On the other hand, households practicing CA can prepare their land during dry season in advance of the rains, reducing the labour demand peak at the start of the rains. In the contrary, CF proponents argued that the CA methods of permanent soil cover and minimum tillage are still labour intensive in the first year though it reduces in the following seasons. This study finding has filled the gap of inadequate knowledge which Malachy *et al.,* (2010) indicated that the impact of CSA technology on food security and livelihood of households has largely been assumed.

Summary

Majority of 81% of households consider that Agro-forestry and prevailing land tenure have enabled them to earn some additional income for their household food consumption and enhanced their crop production/yields. This was attested that crop yields and incomes on adjudicated land was three times higher than on un adjudicated land which has less secure tenure (Neufeldt *et al.,* 2011). Although 54% of households consider that conservation agriculture is more productive than conventional farming, only 44% of them actually practice it in their farms citing resource constraints and limited access to extension services. However, from the findings, there was realization of improvement in food security as households 21.8 per cent were food secure in Makueni County compared to 2 per cent in 2012 which could be attributed to the existence of climate smart fund that support climate related activities of CSA programs.

Conclusions
The study showed that most of households did not receive any subsidized certified seeds and fertilizers from government or from private sector and NGOs as well as not accessing credit during the period under review. This result has exhibited the synergy of CSA technologies and policy makers can be guided by the findings to reconsider the provision of smart subsidies to farmers as in Malawi the fertilizer subsidy resulted in insignificant transformation of the agricultural sector. Therefore, subsidies should be provided as institutional support, pre-financing or policies that recognize and reward practice of CSA or facilitate trade of CSA technologies.

Lastly, farm input access and practising Agroforestry increases crop yields and income and thus food availability, accessibility and affordability. However, majority of households were not able to eat the kinds of foods they preferred because of lack of resources while others ate limited variety of foods due to lack of choices in the market.

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