The Extent of Adopting Climate Smart Agriculture Technologies in Addressing 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 endeavored to assess extent of adoption of climate smart agriculture technologies in addressing household food security. Findings revealed that climate smart agriculture technology accessed and practiced had low adoption on food security. Farmers were willing to adopt technology but cultural factors hindered its adoption. From findings, limited resources was the main constraints to CSA technologies adoption and extension services provision.

Keywords: *Adoption, Climate smart agriculture, Climate smart technologies, Household food security*

Introduction

A country that is food insecure is very vulnerable to other threats that can destabilize the social, economic and political wellbeing of a country. 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: CIAT, 2015). This CSA study provides more understanding to enhance the implementation of the Comprehensive African Agricultural Development Program, (2010) and the Malabo Declaration of the 23rd Ordinary African Union Assembly on Accelerated Agricultural Growth and Transformation as well as contributing to the Kenya's efforts under the *National Adaptation Plan*.

Agriculture in Kenya is facing productivity and food security challenges as a result of inadequate investments in CSA technologies (World Bank, 2015). This situation was exhibited in 2011 when about 3.5 million people were declared food insecure with significant numbers facing chronic hunger after consecutive years of below-average rainfall (AHDR, 2012). 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.

Measuring of adoption rate

Adoption of technological innovations in agriculture has attracted a lot of attention because new technologies have potential to provide an opportunity to increase crop production and income according to Richard *et al.,* 2003 in Jain *et al.,* (2009). These technologies implementation has partial success as demonstrated by observed rates of adoption. These adoption rates or pattern are as per the survey guide on twofold adoption of agricultural technologies developed by CIMMYT (1993) through seeking opinion of farmers (perception) on new technology and carrying out statistical comparison of adoption on the identified technologies. On perception, adopted farmers are asked to explain the reasons for using a technology and/or farmers who not adopt are given opportunity to express reasons for their choice. On the other hand, statistical comparison is by use of statistical analytical tools such as Spearman's ranking correlation, Regression, Chi-square and t-test which compare characteristics of farmers who have adopted a technology.

Climate Smart Cropland Practices

Despite the capacity to potentially generate high yields and farm income thereby enhancing food security, the adoption of climate smart agriculture technologies (CSA) has been relatively low globally (FAO, 2010). Previous empirical studies by Tiruneh *et al.,* (2015) on adoption and diffusion of agricultural innovations attributed the low adoption rate to farmers' decision being influenced by various different factors such as physical and financial capital including access to credit, farm size as well as availability of improved seed and distance to input sources (accessibility). Other factors included access to information on the productivity of the technology and farmers' attitude towards risk on the technologies, out of which those that involve lower risk have greater preference of smallholder farmers as they are more risk-averse.

Water harvesting technologies (RWHTs)

Rainwater harvesting has been in existence for many decades in the World and has positively impacted life, agriculture and economy (Scherr *et al*., 2012). For example, Singapore which has limited resources in terms of land and water has turned heavily to rainwater harvesting with 48 percent of its land is used as water catchment area. According to FARA (2016), cited in Makdaschi *et al.,* (2013) states that water harvesting is part of integrated water resource management technologies which Finger and Bore (2013), refers the major technologies as macro-catchment technologies (flood water, roads surface, runoff utilization, rock catchment, and earth dams); micro-catchment technologies (runoff close to growing crop, zai pits, strip catchment tillage) for growing medium water demanding crops- maize, sorghum and millet; rooftop harvesting technologies. The potential existing in harvesting runoff water and conservation of valley bottom reservoir according to Karina *et al.,* (2011) it supplements crop water requirements without installation of complicated equipment or with only modest investment thereby unleashing the potential for increased household food security.

Liniger *et al.,* (2011) found that an extra 10-25 percent of water runoff harvested and made available during critical periods of plant growth can double or triple crop yields. Despite the recent developments in expansion of rainwater catchment systems in Africa, adoption of rainwater harvesting technologies is slower as compared to other continent (Finger and Bore, 2013). In Kenya adoption of rainwater harvesting techniques (RWHT) is not different from the sub Saharan Africa particularly in Makueni County where despite their potential to improve food security and livelihoods, the households are slowly adopting RWHTs.

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" as cited in Neville (2007) cited in Shitangsu (2013).

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 status of food security and levels of involvement in climate-smart agricultural technologies. A focused group discussion guide was used in selected households to explore extent of adoption 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

This section presents, interprets and discusses the extent of adoption of climate smart Agriculture (CSA) technologies in addressing household food security in Makueni County. The results reflect the demographic characteristics of the respondents and other variables that measured observed rate of adoption by seeking opinion of household (perception) and carrying out statistical comparison of adoption on the identified CSA technologies.

Climate Smart Agriculture Technologies

With regard to climate smart agriculture technologies, respondents were asked to indicate their assessment on access to and knowledge of individual and combined climate smart agriculture technology(s) in relation to their adoption. Their responses were measured on Likert scale where 1=strongly disagree 2=Disagree 3=Neutral 4= Agree 5= strongly agree. Table 1 presents summary of their feedback/responses.

Table 1 Respondents Assessment of Climate Smart Agriculture Technologies

Measure	Score	Frequency	Percent
I have access to farm inputs	Strongly disagree	57	14.3
	Disagree	39	9.8
	Neutral	14	3.5
	Agree	70	17.5
	Strongly Agree	220	55
	Total	400	100
I have access to credit facilities	Strongly disagree	203	50.8
	Disagree	48	12
	Neutral	7	1.8
	Agree	57	14.3
	Strongly Agree	85	21.3
	Total	400	100
I have access to market infrastructure	Strongly disagree	126	31.5
	Disagree	24	6
	Neutral	21	5.3
	Agree	86	21.5
	Strongly Agree	143	35.8
	Total	400	100
I have favorable land tenure system	strongly disagree	73	18.3
	disagree	35	8.8
	Neutral	11	2.8
	agree	87	21.8
	strongly agree	194	48.5
	Total	400	100.0

N=400

Table 2 Respondents Assessment of Climate Smart Agriculture Technologies

Measure	Score	Frequency	Percent
I have knowledge and use agroforestry practices	Strongly disagree	75	18.8
	Disagree	27	6.8
	Neutral	22	5.5
	Agree	69	17.3
	Strongly agree	207	51.8

	Total	400	100
Have access to extension and weather advisory services	Strongly disagree	193	48.3
	Disagree	38	9.5
	Neutral	23	5.8
	agree	65	16.3
	Strongly agree	81	20.3
	Total	400	100
Have access to and use combined climate smart agriculture technologies	Strongly disagree	187	46.8
	Agree	46	11.5
	Neutral	31	7.8
	Agree	52	13
	Strongly agree	84	21
	Total	400	100

N=400

From table 1 and 2, results indicated the climate smart agriculture technologies that were accessed in Makueni County and subsequently affecting their adoption rate. The most accessed CSA technologies for agricultural productivity included farm input at 72.5 percent majority of households, secure land tenure system (70.3%), agroforestry (69. %) and market infrastructure (57.3%) with credit and extension services not widely accessed.

However, majority of households at 62.8 per cent disagreed that they are able to access credit facilities with 57.8 percent of the households also disagreeing that they access extension services and weather advisory services that were important for their adoption. Key informants reported that most households are unable to access credit due to failure to secure guarantors, fear of high interest rates and lastly, farmers not having trust in the financial institutions.

Further the study revealed that 69 percent of the respondents had knowledge and practice agroforestry and 70.3 percent of the households found their current farm tenure system to be favorable for agricultural production and thus an incentive for adoption of CSA technologies.

In general, 34 per cent of surveyed households had access and use combined climate smart agriculture technologies in increasing agricultural productivity which indicates relatively low rate of adoption and diversification of technologies. This finding disagreed with *a national household baseline survey by MoALF, (2014) on implementation status of agricultural sector development support program* that found 52 percent of respondents had accessed to at least one new improved agricultural technology within the previous two years. However, Wekesa *et al.*, (2018) agreed that CSA technologies can be adopted in varied combinations and the adoption rate was still low with many smallholder farmers implementing low capital requirement practices which could have been attributed to resource constraints. The access to market infrastructure (57.3%) influences crop diversification and adoption rate of technologies which Kipkoech *et al.*, (2015) found that access to market provide opportunities for farmers to adopt new technologies and diversify crop production that considerably increased yields and income.

The researcher conducted further test to establish a relationship between access to and use of combined CSA technologies together with awareness and practice of CSA technologies which is a proxy for adoption. The study demonstrated a medium positive correlation of $r = 0.505$ (Table 1) with a statistically significant $p < 0.05$. Correlations analysis revealed that access to and use of combined CSA technologies is positively associated with awareness and practice CSA technologies (Adoption). This inferred that increase in knowledge and practice of CSA technologies increases the probability of households accessing to and using combined CSA technologies, thus the need for vibrant extension advisory services that increases knowledge and adoption. Further, figure 1 present correlations on relationship between individual CSA technology and awareness and practice CSA technologies as proxy for adoption. The Spearman's correlation analyzed relationship between individual CSA technology such as irrigation technique for agricultural production and awareness and practice of CSA technologies and was statistically insignificant at $p > 0.05$, approx. $p = 0.05$. Therefore, this finding shows that there is no association between using irrigation technique for agricultural production and being aware and practicing CSA technologies among the respondents. However, this study revealed that awareness and practice of CSA technologies is positively associated with having access to extension services. This analysis indicated a moderate positive correlation of access to extension services with awareness and practice of CSA technologies ($r = 0.443$) which is statistically significant at $p < 0.05$. $p = 0.000$, implying that extension services is critical for enhancement of knowledge and practice of CSA technologies (Adoption). Further, there was low positive correlation between having favorable land tenure system and awareness and practice of CSA technologies ($r = .109$) which is statistically significant p

< 0.05, p =0.29, revealing a low positive but significant relationship between awareness and practice of CSA technologies and having favorable land tenure system. The results indicated that with increased knowledge on CSA technologies can motivate the government to fast track and expand adjudication together with title issuance program.

Meanwhile, result revealed a weak negative correlation between having knowledge and use of Agroforestry practices and being aware and practice CSA technologies (Adoption) at r = -0.008). The study indicated that the relationship was statistically insignificant at p > 0.05, p= .875, depicting no association between having knowledge and use of agroforestry practices and being aware and practicing CSA technologies among the respondents. This result can be explained by suggestion that knowledgeable or high educated respondents tends to prefer high cost technologies such as agroforestry and irrigation that have diversified risks and thus negative insignificant association. Further, weak positive correlation between having access to market infrastructure and awareness and practice of CSA technologies (r =.128) was observed with statistically significant at p < 0.05, p =0.10. The findings had a low positive but significant relationship between awareness and practice of CSA technologies and having access to market infrastructure meaning that access to market is an enabler to high adoption rate. The same analysis depicted a medium positive correlation between access to credit facilities and awareness and practice of CSA technologies (r = 0.480) which was statistically significant at p < 0.05. p =0.000. Correlations revealed that access to credit facilities is positively strongly associated with having awareness and practice of CSA technologies. This finding suggest that respondents who have increased access to credit are more knowledgeable and practice CSA technologies depicting enhanced adoption rate for CSA technologies.

Further, the researcher sought to examine the households practicing climate smart agriculture technologies such as agroforestry, conservation agriculture, irrigation and extension services with respect to their age. In this regard, the study examined age as a determinant factor in the practicing of climate smart agriculture in Makueni County using Pearson Chi-Square Test. The age categories were 15-25, 26-35, 36-45, 46-55 and over 56 years.

Table 3: Age categories with respect to practicing of CA, agroforestry, Irrigation and Extension Services

	Age Category in years				
CSA Practice	**15-25**	**26-35**	**36-45**	**46-55**	**Over 56**
Conservation Agriculture	37.5%	32.6%	46.9%	59.2%	46.2%
Agroforestry	66.7%	55.1%	64.2%	75.5%	55.8%
Irrigation	47.9%	62.9%	53.1%	53.1%	42.3%
Extension services	2.1%	26.4%	33.5%	47.9%	26.9%

N=400

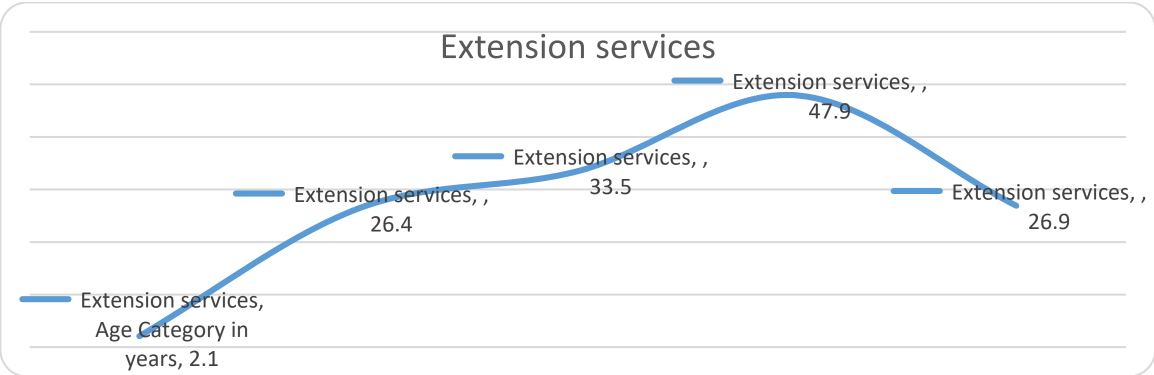

Figure 1: Age versus access to Extension services in CSA

The finding was presented in table 3 and figure 1. The results showed that the youthful households, from 15 to 35 years were not so active in practicing CSA technologies confirming that they migrate to urban areas as compared to the farmers from 36 years and above. For instance, with Conservation agriculture, from ages 15-35 constituted youth at 34.3%, ages 26-35 constituted 32.6%, ages 36-45 were 46.9% while over 56 years were 46.2%. Access to extension services was also determined by age, at 15-25 years, 2.1% reported to have received extension services. The percentages kept on rising to a climax of 47.9%, which constituted households at the age of 46-55 years as the most active respondents adopting and practicing CSA technologies and suddenly declined from the age of 56 years and above to 26.9% of households. This means as the households start to age, they get less involved in agricultural practices. The age over 56 years becomes less active because they do not have the energy, vigor and resources as they used to do. They also decide to give an opportunity to the youthful farmers to take over. Similar findings have been documented by Akinwalere, (2017), in his study on the determinants of adoption of agroforestry practices among farmers in southwest Nigeria.

Awareness and Practice of Climate Smart Agriculture (Adoption rate of different CSA technologies)

With regard to analyzing adoption rate and/or pattern as well as exploring extent of adoption of CSA technologies, the researcher further sought opinion (perception) of households, their proportion that were aware and practiced climate smart agriculture technologies such as conservation agriculture, agroforestry, irrigation, access to credit, input and extension services. Every respondent was asked to indicate whether they were aware and practice climate smart agriculture technologies. Their responses are given on figure 2

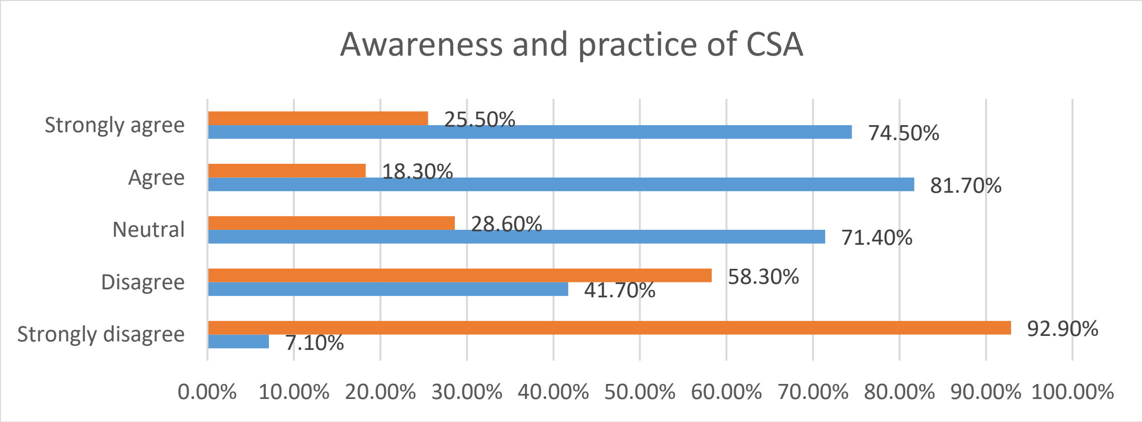

Figure 2 Knowledge and practice of CSA

The study in figure 2 showed that majority of respondents (93%) strongly disagreed that they have knowledge and/or practice climate smart agriculture. This result agreed with the level of education where 36 per cent of the households having acquired primary education and below affecting the choice and investment in CSA technologies coupled with age above 55 years of respondents at 13 percent. This implied that level of education of the respondents can hinder them access credit and extension services thus reducing adoption rate. This agrees with FAO, (2010) that despite the potential of CSA to generate high yields and farm income thereby enhancing household food security, the adoption of CSA technologies has been relatively low globally. In this aspect, Wekesa *et al.*, (2018) attributed this low rate of practice of CSA to resource constraints resulting in implementing low capital agricultural practices such as use of manure and crop residue while Chesterman & Neely, 2015) cited that uncoordinated policies and institutions have potential to undermine the farmers' effort to gain access to inputs and credit.

With respect to knowledge and use of agroforestry practices as preferred low risk CSA technology, the Ministry of agriculture, livestock and fisheries while evaluating the Agricultural Sector Development Support Programme (2014) found that majority at 92 per cent of the farmers surveyed expressed willingness to adopt agroforestry techniques with at least 42 percent of households practiced agroforestry (ASDS, 2010-2020). However, farmers were not knowledgeable about agroforestry as a land-use practice or about the various systems that may be applied on their agricultural farms. In this regard, among those who practiced agroforestry, the evaluation study found that 42 per cent of households were most common planted trees for windbreak, followed by shade trees (37%) and fruit trees at 11 per cent while multi-storey cropping was not very common at 1 percent of households used this system of agroforestry. Gender responsive CSA technologies can lead to the betterment of the lives of different smallholder farmers (Nelson *et al.*, 2016). The study explored five CSA technologies and evaluated how households were involved in the practices and adoption, according to gender.

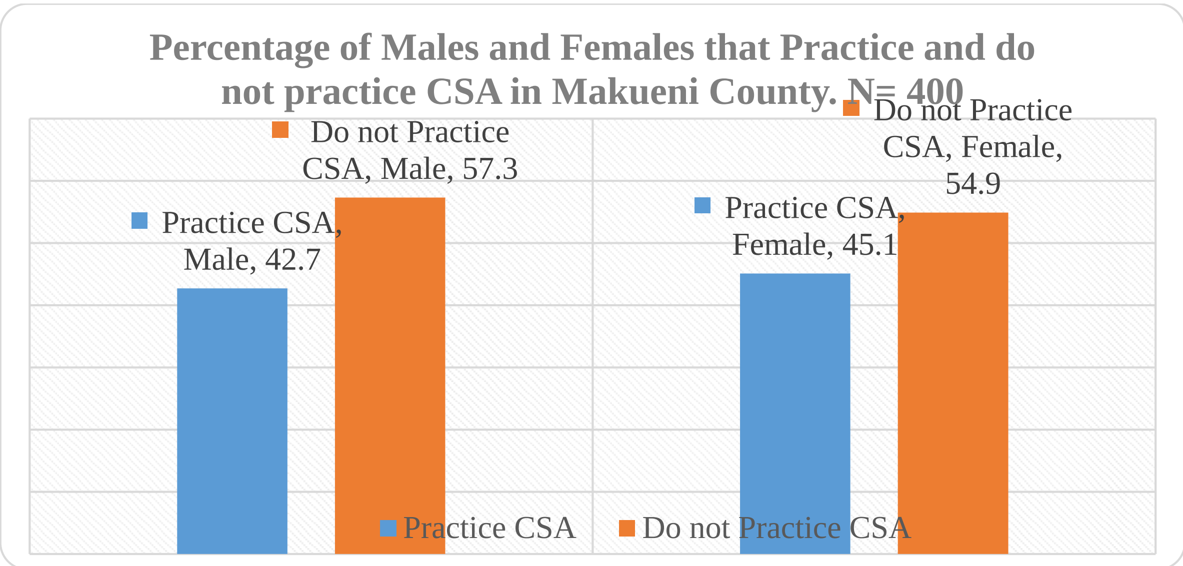

Figure 3: Practice of CSA by Gender

In 2011, Food and Agricultural Organization (FAO) documented that women in the agricultural sector comprises 43 percent in the developing countries. The results of this study in figure 3 indicated percentages of men and women that practices and hence adopted CSA were 42.7 percent and 45.1 percent respectively. The result revealed more women practice CSA than men affirming that the later (men) migrate to urban areas searching for employment, thus the observed high off-farm source of income (31.25%)

of the household in Makueni County. Women have a higher labor burden than men because they engage in unpaid household responsibilities in collecting fuel, fetching water and still afford to dedicate significant time and resources in agriculture (Team *et al.,* 2011). The percentages of men and women involved in climate smart agriculture are comparable an indication that adoption of gender responsive CSA technologies has livelihood benefits such as incomes, ability to access credit and changes in intra-household decision making.

The researcher further sought to determine the level of adoption of different CSA technologies by using statistical comparison of Spearman's Ranking and Correlation of awareness/practice of climate smart agriculture and the individual/combined CSA technologies. Findings are presented on table 4.

Ranking was done in order of strength of spearman correlation analysis to determine adoption level of different CSA technologies.

Table 4 Spearman's Ranking and Correlation

CSA Technologies	Spearman correlation value	Nature of correlation	Level of correlation
Conservation agriculture practice	0.748	Positive and statistically significant	High
Have access to and use combined CSA technologies	0.505	Positive and statistically significant	Medium
have access to Credit facilities	0.489	Positive and statistically significant	Medium
Have access to extension services	0.443	Positive and statistically significant	Medium
I practice water harvesting that I use to farm	.327	Positive and statistically significant	Low
have access to market infrastructure	0.128	Positive and statistically significant	Low
I have favorable land tenure system	0.109	Positive and statistically significant	Low
I use irrigation for my agricultural production	0.037	Positive and statistically insignificant	Low
I have knowledge and use Agroforestry practices	-0.008	Negative and statistically insignificant	Low

There was evidence of statistically significant bivariate and positive association between the household awareness and practice of climate smart agriculture with access to credit facilities, access to market infrastructure, land tenure system, access to extension and weather advisory services together with combined CSA technologies as well as water harvesting techniques. Meanwhile, the association of knowledge and use of agroforestry is negative and not significant to the awareness and practice of climate smart agriculture.

The results presented on Table 4 mean that higher rho coefficients denote a stronger magnitude of relationship between variables. Smaller rho coefficients denote weaker relationships**.** This analysis was used to rank households adoption rate on CSA technologies with evidence showing that conservation agriculture together with combined technologies and household awareness and practice of climate smart agriculture rank highest and medium adoption because of strongest relationship of Spearman's value of rho .748 which is ranked high adoption and .505 ranked medium respectively with strong statistically significant and positive bivariate association. This implied household preferred practicing conservation agriculture and different CSA technologies in their farms to reap the synergy exhibited in the practice of combined technologies and crop diversification. This high adoption rate could have been attributed to households' diversification of climate smart agriculture technologies which had potential of enabling them to invest in risk reduction and high intensive capital techniques and practices such as conservation agriculture and irrigation which can stabilize food production.

Further, access to credit facilities (rho .480) and access to extension and weather advisory services at rho.443 are ranked medium followed by water harvesting techniques at rho.327 ranked low. These technologies had positive correlation which was statistically significant at the 0.01 level (2-tailed). Further, the other technologies had low adoption level with rho value of .128 and .109 for access to market infrastructure and having favorable secure land tenure system respectively with positive correlation which was significant at the 0.05 level (2-tailed). Surprisingly, use of irrigation for agricultural production and access to input had low adoption rate with spearman's rho value of .037 and .030 respectively, implying a positive relationship with climate smart agriculture but not statistically significant which could have been attributed to the fewer households who accessed farm input and practiced irrigation as these technologies are high intensive capital investment. The finding was similar to that of Kipkoech *et al.,* (2015) who opined that existing policies target smallholder farmers who lack resources to adopt innovations such as CSA technologies. This leads to the slow rate of up-take (adoption) of innovations such as use of improved seeds, agroforestry and irrigation agriculture particularly in short term due to significant cost involved. The practice of wide range of CSA technologies has the potential to increase food production and enhance the resilience of food production systems, thus CSA should be embedded into National Agriculture Food Security and Investment Plan as well as the Sendai Framework to transform food system and reduce vulnerability of households to effects of disaster risks such as climate change, drought and floods.

Another interesting finding was on the low adoption level of agroforestry practice which had spearmen's value of -.008, indicating a negative relationship with climate smart agriculture awareness and practice that is not statistically significant. This contrast with findings of this study when research questions on agroforestry systems and practices sought to determine whether households practice agroforestry and the result was that majority of households at 62.8 percent practice agroforestry with majority of 251 households that practice agroforestry involved in multistory tree garden at 77.7 percent as the preferred agroforestry system. However, the adoption of agroforestry with the least spearman's rho value (-.008) agrees with other studies by Dawson *et al.*, (2013) who called for understanding why there has not been wider uptake of agroforestry in Ethiopia, Kenya, Tanzania and Uganda, thus suggesting for policy makers to reorient and promote agroforestry as a climate smart land use practice through embracing tree and land tenure policy as well as addressing the constraints including inadequate knowledge to enhance crop yields and farm income, thus increasing food security in Makueni county and other ASALs in the country.

Cropland Management Practices

The study further sought to establish various cropland management practices in use by households. For instance, households were asked whether they received subsidized fertilizers and seeds from government and whether they use pesticides, herbicides, fungicides to control crop diseases to boost their yields. Table 6 presents responses.

Table 5a Statement on Access to Farm Inputs

Variable	Score	Frequency	Percent
I get subsidized fertilizer from government	Strongly disagree	261	65.3
	Disagree	59	14.8
	Neutral	14	3.5
	Agree	29	7.3
	Strongly agree	37	9.3
	Total	**400**	**100.0**
I use organic fertilizer from my farm	Strongly disagree	82	20.5
	Disagree	25	6.3
	Neutral	13	3.3
	Agree	66	16.5
	Strongly agree	214	53.5
	Total	**400**	**100.0**
I get subsidized certified seeds from government	Strongly disagree	306	76.5
	Disagree	65	16.3
	Neutral	16	4.0
	Agree	5	1.3
	Strongly agree	8	2.0
	Total	**400**	**100.0**
I get subsidized seeds from private sector and NGOs	Strongly disagree	298	74.5
	Disagree	45	11.3
	Neutral	10	2.5
	Agree	4	1.0
	Strongly agree	43	10.8
	Total	**400**	**100.0**

N=400

Table 5b Statement on Access to Farm Inputs

Variable	Score	Frequency	Percent
I use mechanized services from county	Strongly disagree	335	83.8

government to farm	Disagree	43	10.8
	Neutrality	15	3.8
	Agree	3	.8
	Strongly agree	4	1.0
	Total	**400**	**100.0**
I hire mechanized services to farm	Strongly disagree	223	55.8
	Disagree	28	7.0
	Neutral	20	5.0
	Agree	44	11.0
	Strongly agree	85	21.3
	Total	**400**	**100.0**
I use pesticides, herbicides, fungicides to control crop diseases	Strongly disagree	77	19.3
	Disagree	18	4.5
	Neutral	20	5.0
	Agree	82	20.5
	Strongly agree	203	50.8
	Total	**400**	**100.0**
I don't use inorganic fertilizer because it is expensive, and I cannot afford it	Strongly disagree	242	60.5
	Disagree	54	13.5
	Neutral	19	4.8
	Agree	27	6.8
	Strongly agree	58	14.5
	Total	**400**	**100.0**

N=400

Table 5 (a) shows the results of the assessment on access to farm input with respect to received subsidized inputs, use of organic fertilizers and pesticides as climate smart cropland practices. The results indicated the level of households accessed to farm input in Makueni County between 2017- 2018 as follows: majority of households surveyed (80.1%) did not receive any subsidized fertilizer from national government, 92.8 percent did not receive subsidized certified seeds from county government and 85.8 percent did not get subsidized seeds from private sector and NGOs. Results further showed as presented in table 5b, that 94.5 percent did not use mechanized services from Makueni County Government to farm. Higher proportion of respondents (70%) also affirmed that they use organic fertilizer from their farms to undertake farming activities, whereas similar proportion at 71.3% confirmed that they use pesticides, herbicides, fungicides to control crop diseases. Study also showed that majority of households at 74 per cent does not use inorganic fertilizers in the farms as they find them to be very expensive that they cannot afford. Similarly, majority at 94.6 per cent of the respondents confirmed that they do not use tractors from county government to farm while only 32 per cent hire tractor to prepare their land.

The findings of this study indicate that the public sector (national government, county government) and private sector did not provide subsidized inputs making household not to adequately adopt the climate smart cropland practices. This leads to low crop yields and incomes affecting food availability and accessibility, thus negatively influencing household food security in Makueni County. This result is consistent with Kenya's *Policy framework (ASDS, 2010-2020)* which states that adoption of improved inputs by household farmers is relatively low. For instance, Mwangangi *et al.,* (2012) in their study on *Baseline Household Survey* in Makueni, Kenya found that more than 94 per cent of the households do not use fertilizer. This is attributed to cost implication and high risk of crop failure because rains are not reliable and farmers do not risk investing a lot in rain fed seasonal crops. However, organic fertilizer (Farm yard manure) and pesticides are applied to fruit trees and irrigated vegetables which are major sources of income in the farms (in-farm income). This finding is in consistent with a study by Kipkoech *et al.,* (2015) who observed that organic fertilizers from household organic wastes and farm yard manure were the widely used form of fertilizers and is a climate smart option that increases yields. Similarly, this result is in conformity with that of Mwangagi *et al.,* (2012) who explained the use of pesticides (84 per cent of respondents) on mango and citrus as major crops in the county and pesticides use is a must for realizing meaningful yields.

Separately, this finding contrast that of Ochola *et al.,* (2015) who found that the Government of Kenya has created and sustained a relatively stable policy environment, financing infrastructure and supporting fertilizer markets to encourage household farmers' access to climate smart cropland subsidies. This was through the Ksh. 36 billion input subsidy programme- *The National Accelerated Agricultural Input Programme* that created demand for extension services, input, market, credit and partnerships resulting in increased maize production from 4 to 20 bags per acres and reduced distances to input sources from 15 to 35 km to 3 to 9 km thus increased household food security. This is indicative of great potential of climate smart subsidies only that there is need to be provided to initiatives that support and promote CSA in ASAL and beyond.

Agricultural extension and advisory services

The researcher lastly sought to establish whether households received agricultural extension and advisory services during the period of review. Responses are presented on table 6

Table 6 Agricultural extension and advisory services

Measure	Score	Frequency	Percent
Ever received extension services advice	yes	114	28.5
	No	286	71.5
	Total	**400**	**100.0**
Source of extension services	Public sector (National and county government, parastatal, research and training institutions)	46	40.4
	Private sector (companies, civil societies, NGOs, FBOs, CBOs)	33	28.9
	Contact farmers	16	14.0
	Traders	3	2.6
	Agriculture bulletin, newspaper or magazine	1	.9
	Agricultural programmes in radio and Television	9	7.9
	Membership of farmers' informal group	2	1.8
	Agricultural Mobile phone Applications	4	3.5
	Total	**114**	**100.0**
Contact with extension services	Very frequent - Once per every two weeks	6	5.3
	Frequent - Once per month	38	33.3
	Not frequent - Once per three months	30	26.3
	Irregular -When I have a problem	40	35.1
	Total	**114**	**100.0**
Are extension services accessible?	Strongly disagree	176	44.0
	Disagree	55	13.8
	Neutral	58	14.5
	Agree	46	11.5
	Strongly agree	65	16.3
	Total	**400**	**100.0**

Table 6 shows that majority of households at 71.5 percent have never ever received advice on agriculture from extension services officers in years 2017/2018 with majority of 114 households that confirmed to have received extension services, 40.4 percent stating their main source was public sector that comprise of national and Makueni county government, parastatal, research and training institutions and 28.9 per cent private sector. This is in line with policy guidance as government efforts to include but not limited to adoption of a sector wide approach to provide extension services whereby public and private sector are involved (World Bank, 2011). This finding when corroborated with FGD sessions, the participants confirmed that County Government had employed extension service officers who are expected to support farmers at grassroots level. However, the study findings show that extension officers have interacted with selected villages and sub counties and therefore are not covering the entire county. Moreover, the study showed that even in those areas and households that received extension services during the year under review, majority of respondents at 35.1 percent stated that they consider contact with extension service providers to be irregular and they only received those services only when they had problems in their agricultural practice.

This finding was affirmed by respondents at 57.8 per cent that indeed, extension services is not accessible and according to (World Bank, 2011) it affect dissemination and adoption of CSA technologies due to low level of knowledge from declining extension services as a result of reduced operational budget and human resources in the sector Ministry of Agriculture. Another study by Kipkugat *et al.*, (2015) observed rapid decline in agricultural extension services affecting the living status of small scale farmers in Wereng Sub County, in Uasin Gishu County. Separately, Wekesa *et al.*, (2018) underscored that extension services influences agricultural production and income through sharing knowledge, technologies, agricultural information and linking the farmer to other actors in the economy. This study indicate the need to reorient the conventional extension policy approach to enhance contact of extension services with farmers through the farmer-to farmer (FtF) extension approach as promoted in Ethiopia according to Tiruneh *et al.*, (2015).

Further, the same researchers (Wekesa *et al.*, 2018) suggested that technology innovation and transfer can be through group membership and belonging to a farmer group increased the probability of adopting CSA technologies by18.8 per cent. This means those farmers groups are important channels through which extension agents can use to access farmers thereby increasing the number of contacts with extension services providers. In this regard, one more annual contact with extension agents increased the probability of adopting CSA by 0.46 per cent and thus increasing crop yields and income. This study finding has provided insight into the potential contribution of agricultural extension services to household food security in Makueni County which concurs with suggestion by (Abdi & Worth, 2011) that it is of value to establish how agricultural extension services and advisory can contribute to achieving food security.

Summary

The study showed that only 43.3 percent of the respondents were aware and use climate smart agriculture (CSA) technologies. This result was corroborated and found to be attributed to majority of respondents (93%) strongly disagreed that they have knowledge and/or practice climate smart agriculture. This could have been due to level of education where 36 per cent of the households had acquired primary education and below affecting the choice and investment in CSA technologies by impeding them from access to extension services and credit.

This Spearman ranking Correlation analysis on adoption levels (High, Medium and Low) of climate smart agriculture technologies showed that conservation agriculture together with access to and use of combined technologies ranked high (value of rho .748) and medium (.505) respectively with strong statistically significant and positive bivariate association. This implied household preferred practicing different CSA technologies in their farms to reap the synergy in the combined practice through diversification of climate smart technologies which have potential in risk reduction and high intensive capital such as conservation agriculture and irrigation thus stabilizing food production. Further, the other technologies had adoption level with rho value of .128 and .109 for access to market infrastructure and having favorable land tenure system respectively with positive correlation which was significant at the 0.05 level (2-tailed). Surprisingly, use of irrigation and access to input had spearman's rho value of.037 and .030 (both low) respectively, implying a positive relationship with climate smart agriculture but not statistically significant which could have been attributed to the fewer households who accessed farm input and practiced irrigation because these technologies demand for high intensive capital investment.

On the adoption level of agroforestry practice interestingly had spearmen's value of rho -.008, indicating a negative relationship with awareness and practice climate smart agriculture that is not statistically significant. This contrast with findings of this study when research questions on agroforestry systems and practices sought to determine whether households practice agroforestry and the result was that majority of households at 62.8 percent practice agroforestry. However, the adoption level of agroforestry (-.008) agrees with Dawson *et al.*, (2013) who called for understanding why there has not been wider uptake of agroforestry in Ethiopia, Kenya, Tanzania and Uganda. This could have been attributed to farmers being not knowledgeable about agroforestry as a land-use practice or about the various systems that may be applied on their agricultural farms.

Lastly, evidence has showed that majority of households did not access credit during the period under review. CSA technologies practiced like agroforestry require farmers to have access to specific inputs, such as tree seedlings, seeds or fertilizers and lack of such inputs constrains widespread adoption.

Conclusion

The study shows that majority of households do not have knowledge and/or practice conservation agriculture (CA) though it has the highest positive and significant adoption rate of the climate smart agriculture (CSA) technologies. Despite more than half of household's surveyed practice CA, majority are not comfortable practicing this new method of agriculture due to lack of knowledge and resource constraints. However, adoption of wide range of combined CSA technologies was ranked medium adoption level after (CA) and has the potential to increase food production, income and enhance the resilience to climate change. In this regard, CSA should be mainstreamed into National Agriculture Food Security and Investment Plan as well as incorporated in the Sendai Framework to transform food system and reduce vulnerability of households to effects of disaster risks such as climate change, drought and floods. The study further revealed that limited resources was one of the main constraints to CSA technologies adoption more so provision of extension services.

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