Tanzania Journal of Development Studies, Vol. 20, No. 1, 2022: 136-156

Opportunities and Challenges Experienced by Smallholder Farmers in Using Climate Smart Agriculture to Adapt to Climate Variability and Change in Kilosa District, Tanzania

Zacharia Silas[*] *& Patrick M. Ndaki***

Abstract

This study assesses opportunities and challenges experienced by smallholder farmers in using climate smart agriculture (CSA) to adapt to climate change and variability in Kilosa District, Tanzania. The objective of this study was to establish the opportunities and challenges that arise due to the adoption of CSA practises in enhancing crop production and adaptive capacity in improving food security among smallholder farmers. Data were collected from 100 purposively selected crop farmers' households using a questionnaire, focus group discussions, and observation; as well as conducting transect walks. Obtained quantitative data were analysed using frequency counts, percentages and inferential statistics, in particular chi-square cross-tabulation to determine relationships between variables. The analysis of qualitative data involved the identification, examination and interpretation of patterns and themes that arose from the textual data. Findings revealed that the opportunities brought about by climatic smart agriculture included high demand for minimum water usage technologies, and the adoption of drought-resistant crop varieties. Shortened rains, conflicts between farmers and livestock keepers, and the lack of CSA knowledge were found to be the major challenges. The study concluded that CSA practises are of potential benefits in the adaptation to climate change and/or variability. The study recommends supporting services such as agricultural subsidies, technologies, trainings in CSA practises and funding to smallholder farmers to enhance their adaptive capacity and long-term resilience to adverse impacts of climate change and variability.

Keywords: *opportunities, challenges, smallholder farmers, climate smart agriculture, adaptation, climate variability and climate.*

Introduction

Background Information

The concept of climate-smart agriculture (CSA) was first introduced by the United Nation Food and Agriculture (FAO) in 2010 during the Hague Conference on agriculture, food security and climate change (FAO, 2010). The aim of climate smart agriculture was to tackle three main objectives, namely: sustainably increase food security by increasing agricultural productivity and incomes; build resilience and adaptive capacity to climate change; and reduce and/or remove greenhouse gas emissions where possible (FAO, 2013; Alexander, 2019). Climate-smart agriculture is an approach to help guide actions to transform and reorient

[*]Banyire Community Development Support Foundation, Dar es Salaam, Tanzania: smzacharia89@gmail.com
** Institute of Resource Assessment (IRA)/Center for Climate Change Studies, University of Dar es Salaam, Tanzania: pattymzee@gmail.com

agricultural systems to support development and food security effectively and sustainably under changing climate (Lipper et al., 2014; Ogada et al., 2018;). It is not a new production system, but a means for identifying production systems and enabling institutions to be best-suited to respond to the challenges brought by climate change in specific locations so as to maintain and enhance the capacity of agriculture to support food security in a sustainable way (Rosenstock, 2016; Mwongera et al., 2017; Ogada et al., 2018).

Climate-smart agriculture includes proven practical techniques such as mulching, intercropping, conservation agriculture, crop rotation, integrated crop-livestock management, agro-forestry, improved grazing and improved water management (Schaafsma & Bell, 2018; Ogada et al., 2018). Besides, it also includes innovative practises such as better weather forecasting, early-warning systems and risk insurance (Boydell et al., 2018). In other words, climate smart agriculture is about getting existing technologies off the shelf and putting them in the hands of farmers, and further developing new technologies such as drought- or flood-tolerant crops to meet the demands of the changing climate (White et al., 2017; Boydell et al., 2018). In Tanzania, several projects to adapt to climate change impacts are already in place at both national and community levels. For example, the main objective of the District Agricultural Sector Investment Project (DASIP), implemented by Tanzania's Ministry of Agriculture, is to increase agricultural productivity and incomes of rural households in the project areas (DASIP, 2016); while that of the Monitoring African Food and Agricultural Policies (MAFAP) is to set up a sustainable system for monitoring the impact of food and agricultural policies (MAFAP, 2013).

In Kilosa District, the Department of Agriculture indicated that various CSA-related practises are being undertaken by different stakeholders. For example, AGRA introduced drought-resistant varieties such as pigeon peas in 2011; while the International Centre for Research in Agro-Forestry (ICRAF) introduced cow peas, maize and paddy seeds that are resistant to drought and diseases while producing higher yields per acreage. Furthermore, an irrigation scheme project was introduced by the Ecosystem Restoration Program Plan (ERPP) in Mvumi village. The 2017 report from the Department of Agriculture in Kilosa District indicates that about 7 irrigation schemes were established in the district to support irrigation farming in the context of CSA practices. Furthermore, in 2015, Swiss Contact—an NGO from Switzerland—introduced drip irrigation in Ilonga, Kilosa District, to support tomato production involving 60 youths.

According to Mkambala (2016), district and village adaptation plans for Kilosa District complimented already existing initiatives at the community level. At the district level, various CSA interventions have been carried out based on identified impacts of climate change. Interventions included the utilization of improved seed varieties and irrigation infrastructures, improved farm management practises such as the use of organic as well as inorganic fertilizers, integrated pest management, conservation agriculture, and rainwater harvesting technologies (ibid.). It is due to this background that this study strived to assess the opportunities and challenges that arose due to the application of CSA interventions in Kilosa District in enhancing adaptive capacity and improving food security among smallholder farmers, amidst climate change and variability.

Objectives of the Study

The main objective of this study was to establish the opportunities and challenges in the adoption of CSA practices in enhancing crop production and adaptive capacity in improving food security among smallholder farmers. Specifically, the study aimed to identify farmers' knowledge level on climate-smart agriculture, explore adopted types of climate-smart agriculture, and identify available opportunities and challenges experienced by smallholder farmers in adopting climate-smart agriculture in Kilosa District.

Study Area

The study was conducted in Kilosa, a district in Morogoro Region, located in east-central Tanzania, 300km west of Dar es Salaam. It lies between Latitudes 5˚55' and 7˚53' South, and Longitudes 36˚30' and 37˚30' East. The district covers an area of 14,245km² (URT, 2015).

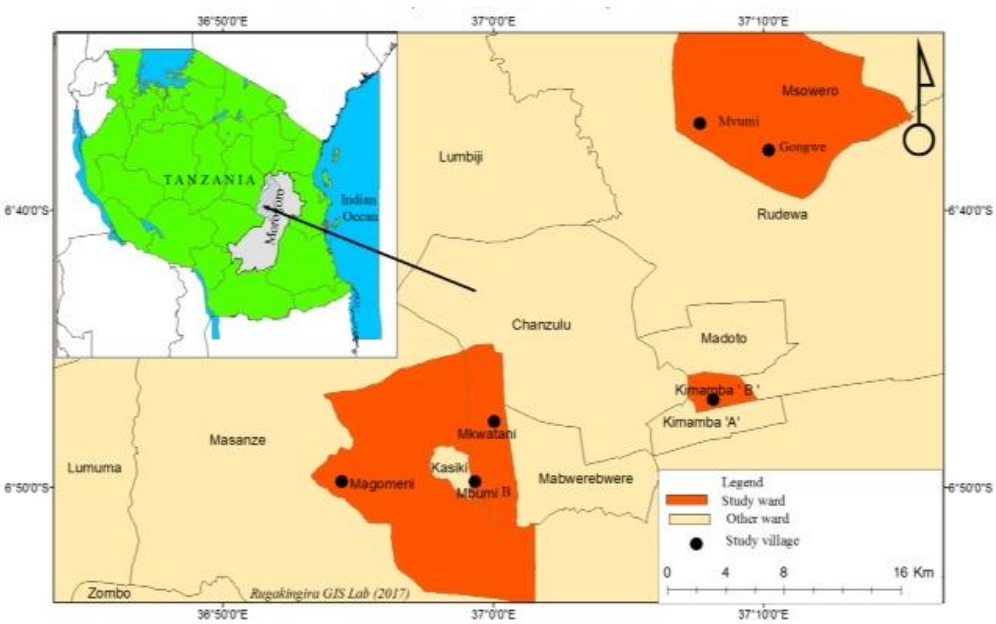

Figure 1: Study Villages in Kilosa District

Source: Own construct

Justification

The selection of the study sites was informed by the fact that about eight (8) CSA-related interventions were implemented in the district in the past few years. They included the adoption of improved seed varieties, improved as well as managed irrigation infrastructures, farm management practises, use of organic as well as inorganic fertilizers, integrated pest management, strengthened community weather information system, rainwater harvesting, and conservation agriculture (Mkambala, 2016). These formed the basis for the implementation of adaptation plans at both village and district levels within Kilosa District (ibid.). Nambiza (2013) also ascertained that CSA practices—such as conservation agriculture, crop rotation, reduced tillage and terraces—had long been adopted in Kilosa District. Moreover, the district was selected because it was one of the districts that has been highly affected by farmers-pastoral conflicts (Yusuph, 2014), and the fact that many scholars have suggested CSA as one of the solutions to the problem (Mung'ong'o et. al., 2003).

Literature Review

The climate-smart agriculture (CSA) concept reflects an ambition to further integrate agricultural development and climate responsiveness. CSA also aims to achieve food security and broader development goals under a changing climate and increasing food demand. Thus, CSA initiatives sustainably increase productivity, enhance resilience, and minimize greenhouse gas emissions. Hence, CSA is an agriculture that sustainably increases productivity and income, increases ability to adopt, builds community resilience to climate change, enhances food and nutrition security: and does all of these while achieving mitigation co-benefits (CIAT; World Bank, 2017).

The agriculture sector in Tanzania is an important catalyst for economic growth, poverty alleviation and food security. However, one of the major factors constraining sustainable agriculture development in the country is the low investments and failure to support the adoption of improved agricultural practises and technologies. For instance, inefficient extension services is caused not only by the shortage of extension staff and facilities, but also by the limited knowledge on the part of extension officers as regards to appropriate agricultural practises and technologies: these issues leads to inadequate capacity to scale-up agricultural productivity at village and ward levels.

According to the IPCC (2014), climate has changed, and continues to change. The URT (2007) report that Tanzania has experienced an increase in temperature over the last 30 years. Similarly, Davies and Thornton (2011) noted that Tanzania is already experiencing an increase in extreme weather conditions with higher incidences and more prolonged periods of flooding and drought; alongside with prolonged rainfall shortages. Shifts of rainfall seasons and increasing rainfall intensities have been a common phenomenon in many parts of the country resulting from climate change (ibid.). According to Mbilinyi et al. (2013), even farmers themselves have acknowledged observing more changes in rainfall seasons and patterns of temperature in some areas than it was before; with increased incidences of extreme events such as floods and droughts. Other scholars asserts that that global climate change and population growth are two major problems facing the world today, and are linked to food quality and quantity (Shemsanga et al., 2010). In Tanzania, the debate on climate change impacts and adaptation has largely focused on yield and has mostly ignored major pressing issues such as food security, poverty and water availability within the country which all interconnected with climate change. Thus, this calls for the adoption of CSA to address such issues. According to FAO (2017), the response of the private sector and CSOs in Tanzania to provide extension delivery and create incentives for farmers to adopt CSA is still low. It is this context that this study intends delve into how the CSA approach in Tanzania can be designed to identify sustainable agricultural development within explicit parameters of climate change and climate variability (URT, 2015).

Materials and Methods

Research Design

The study used mixed research methods that combined both quantitative and qualitative research approaches. Thus, both quantitative and qualitative methods were used to collect data in a single phase of data collection. In the case of the quantitative research method, data were collected through a questionnaire survey administered to smallholder farmers from six (6) villages in the study area. For qualitative data, interviews were conducted with experts, selected elders and local leaders; while focus group discussions (FGDs) were also conducted with selected smallholder farmers. Transect walks and observation were also used to supplement the main instruments.

Sample Size and Sampling Procedures

According to Tanzania's 2012 national population census, the study area had a total population of 26,060 people. Based on the fact that the study aimed to collect information from smallholder farmers on CSA practices, the study adopted a multistage sampling technique to obtain a reasonable sample size. First, four (4) wards were randomly selected, followed by purposive sampling to select six (6) villages. The focus was on villages under the Climate Change Agriculture and Poverty Alleviation Project (CCAP), as well as those practicing CSA. The selected villages included Mvumi, Gongwe, Kimamba 'B', Mbumi, Magomeni, and Mkwatani (see Figure 1). Besides, 100 households were randomly selected using sampling proportional to size: 27 and 18 respondents from Kimamba 'B' and Mvumi, respectively, were selected; while 17 and 26 respondents from Gongwe and Magomeni, respectively, were selected; as well as 5 and 7 respondents from Mkwatani and Mbumi,. The sampling units were households involved in CSA. The selection of interviewees was purposively made under the guidance of the extension officers of respective wards and villages.

Data Analysis

The collected data were cleaned, summarized, coded and entered in the International Business Machine (IBM) SPSS Statistical Package, Version 20 for analysis. Descriptive statistics such as frequencies, as well as total percentages, were generated. Chi-square tests were used to determine relationships between variables.

Results and Discussion

With regard to the sex of the respondents, there were 69 males, while 31 were females; which constituted 69.7 percent and 30.3 percent, respectively, of the study sample (Table 1).

Table 1: Number of Males and Females and Their Percentages Across the Surveyed Villages

Sex	Kimamba B	Mvumi	Gongwe	Mkwatani	Magomeni	Mbumi B	Total
Male	20	12	14	2	20	1	**69** **69.7%**
Female	8	6	3	2	6	6	**31** **30.3%**
Total	**28**	**18**	**17**	**4**	**26**	**7**	**100** **100.0%**

Source: Household survey, 2017

From the cross-tabulation in Table 2, it is obvious that most of the people in all ages were farmers.

Table 2: Relationship between the Age of the Respondent and Dependence on Agriculture as an Occupation

Age of the respondent * Occupation Farmer Cross-tabulation				
		Occupation Farmer		
		Yes	***No***	**Total**
Age of respondent	15-24	9	0	9
	25-34	11	0	11
	35-44	35	0	35
	45-54	27	0	27
	55-64	5	1	6
	65+	12	0	12
Total		**99**	**1**	**100**

Source: Field survey, 2017

The cross-tabulation in Table 3 shows that irrespective of the sex of a respondent, production is still on a significant ratio between both sexes, i.e., both sexes were involved in crop production.

Table 3 Relationship between Level of Productivity and Sex of Respondents

Level of productivity * Sex of the respondent cross tabulation				
		Sex of Respondent		
		Male	***Female***	**Total**
Level of productivity	High	23	8	31
	Medium	34	22	55
	Low	12	1	13
Total		**69**	**31**	**100**

Source: household field survey, 2017

Table 4 shows that there is no relationship between the sexes of respondents and their productivity level at chi-square = 5.060, *p*-value = 0.080, and $\alpha = 0.05$.

Table 4: Relationship Between Sexes of Respondents and Their Productivity Level

	Chi-Square Tests		
	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	5.060[a]	2	.080
Likelihood Ratio	5.857	2	.053
Linear-by-Linear Association	.275	1	.600
N of Valid Cases	100		

Note: [a] 1 cells (16.7%) have expected count less than 5. The minimum expected count is 3.94

Household Heads' Knowledge and Perception on CSA practices

Table 5 portrays results about household heads' knowledge and perception on CSA: 67 percent of the sampled household heads were aware of CSA practices, while 33 percent were not aware of CSA practices.

Table 5: Household Heads' Knowledge and Perception on CSA practices

Survey question	Frequency	Percentage
Household heads' knowledge and perception on CSA practices		
Yes	67	67
No	33	33

Source: Household survey (2017).

Thus, the results portray that at least most smallholder farmers seemed to be aware of the CSA practices in the study area. This was due to the fact that most households in the study area had received training on climate change and climate smart agriculture from members of a non-governmental organization (NGO) that operated under the REDD+ Project (Nambiza, 2013). Furthermore, the presence of the Ilonga Institute of Research in the study district, which researches on different varieties of agricultural crops, contributed to raising the awareness of CSA practices among smallholder farmers in the area.

Table 6 reveals that there is a relationship between being a resident of the district, and being acquainted with the knowledge of using CSA. Thus, the two variables are dependent at chi-square = 10.579, p-value = 0.005, and significance level = 5%.

Table 6: Relationship between Respondents in the District and Knowledge of CSA

	Chi-Square Tests		
	Value	***df***	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	10.579[a]	2	.005
Likelihood Ratio	11.910	2	.003
Linear-by-Linear Association	5.015	1	.025
N of Valid Cases	100		

Symmetric Measures			
		Value	Approximate Significance
Nominal by Nominal	Phi	.325	.005
	Cramer's V	.325	.005
N of Valid Cases		100	

Note: a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.72
Source: Household survey (2017

Since *p*-value is less than the significance level, then the variables are related; but the relationship is found to be moderate since Cramer's V = 0.325.

Table 7 presents the relationship between respondents' CSA knowledge, and the level of productivity. From the observed chi-square and cross-tabulations, there is no statistically significant relationship between lacking CSA knowledge and productivity level, with chi-square = 0.157, *p*-value = 0.924, which is greater than α = 0.05. Also, the expected counts from the cross-tabulation KKK proved that the expected value and the actual count are not that different. Therefore, having, or not having CSA knowledge, has no relationship with one having higher or lower productivity levels.

Table 7: Relationship between the Respondents who lack CSA Knowledge or Not and the Level of Productivity

Lack of CSA knowledge * Level of Productivities Cross-tabulation						
			Level of productivities			Total
			High	*Medium*	*Low*	
Lack of CSA knowledge	Yes	Count	28	51	12	91
		Expected Count	28.5	50.6	11.9	91.0
	No	Count	4	4	1	8
		Expected Count	2.5	4.4	1.1	8.0
Total		Count	32	55	13	100
		Expected Count	32.0	55.0	13.0	100

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.157[a]	2	.924
Likelihood Ratio	.153	2	.926
Linear-by-Linear Association	.097	1	.755
N of Valid Cases	99		

Note: a. 3 cells (50.0%) have expected count less than 5. The minimum expected count is 1.05
Source: Household survey, (2017

Types of CSA Practices Adopted by Smallholder Farmers in Kilosa District

CSA involves a range of various agricultural and land management practises. However, CSA definition and suitability of use are based on an agro-ecological zone of a particular locality (Yusuph, 2014). Generally, in the studied villages in Kilosa District, the adopted types of CSA practices included minimum/reduced tillage, contour farming and terracing (*soil management*) by 6 percent; and irrigation schemes and drip irrigation (*improved water management*) by 27.5 percent. Others included crop residues incorporation; intercropping and crop rotation (*crop management*) by 30 percent; adoption of drought-resistance crop types by 36.5 percent; and agro-forestry type of CSA (reported to be a new terminology, and thus its aspects were unknown to the sampled respondents in the study villages). However, during interviews with district agricultural officers (DAOs), one member explained that they had started to encourage smallholder farmers to practise agro-forestry.

Table 8: Types of CSA Practices Known by Smallholder Farmers in Kilosa

Survey question	Frequency	Percentage
Types of CSA practices known by smallholder farmers		
Soil management	6	6
Improved water management	27.5	27.5
Crop management practises	30	30
Adoption of drought-resistant crops	36.5	36.5

Source: Household survey (February, 2017).

Figure 3 summarizes the adopted types of CSA practices, with their extent of being practiced in each studied village of the district. For instance, at Kimamba village, 92.6 percent adopted drought-resistant crop varieties, 40.7 percent adopted crop management, 18.5 percent adopted improved water management, and 3.7 percent adopted soil management.

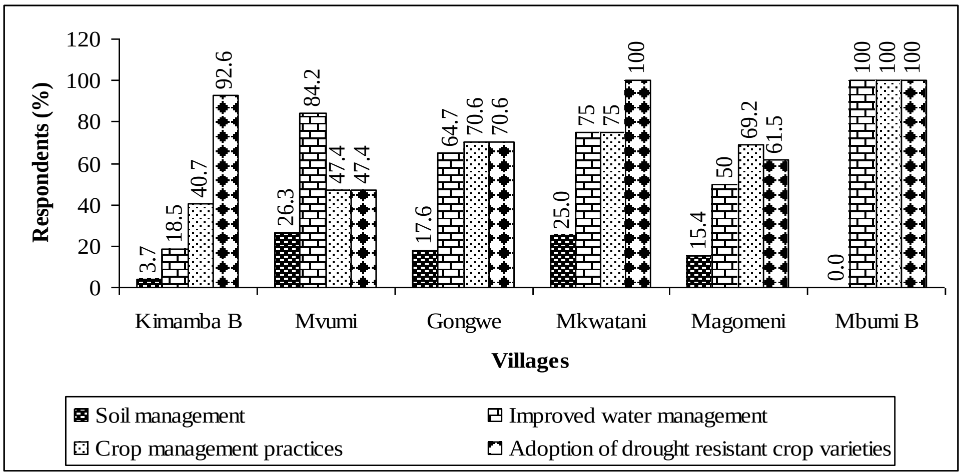

Figure 3: Types of CSA Practices Adopted by Smallholder Farmers Kilosa
Source: Household Survey (February, 2017).

In Mvumi village, 84.2 percent adopted improved water management, 47.4 percent adopted drought-resistant crop varieties as well as crop management, and 26.3 percent adopted soil management. In Gongwe village, 70.6 percent adopted drought-resistant crop varieties as well as crop management, 64.7 percent adopted improved water management, while 17.6 percent adopted soil management.

All respondents in Mkwatani village said they adopted drought-resistant crop varieties, while 75 percent adopted crop management and improved water management, and 25 percent adopted soil management. In Magomeni village, 69.2 percent adopted crop management, 61.5 percent adopted drought-resistant crop varieties, and 15.4 percent adopted soil management. All respondents from Mbumi village adopted drought-resistant crop varieties, crop management, and improved water management.

Figure 3 further reveals that each village had a unique extent of how they adopted a particular type of a CSA practice. For instance, Kimamba B villagers adopted more drought-resistant crop varieties than other types of CSA; Mvumi villagers adopted highly improved water management, and Gongwe villagers adopted drought-resistant crop varieties and crop management types of CSA practices. Mkwatani villagers highly adopted drought-resistant crop varieties; Magomeni villagers adopted crop management, while Mbumi villagers adopted fairly drought-resistance crop varieties and crop management, as well as improved water management. However, the adoptions of particular types of CSA practices in the studied villages depended much on the geographical location of that particular area, and the level of adopted knowledge on the stated aspects of CSA.

Those who used irrigation systems revealed that they dig irrigation ditches from big built channels deviated from the main river and direct the waters to their farms, particularly paddy farms and vegetable gardens. Photo 1 presents a system of rice intensification (SRI) through irrigation found at Mvumi ward in Kilosa District. The ditch built from the river is directed to the farms to ensure water availability throughout the year. Here, they use less water to produce high crop yields.

Photo 1: Irrigation Schemes
Source: Field survey (February, 2017).

Drip irrigation is a form of irrigation that saves water and fertilizers by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing and emitters (Goyal, 2012). It is done through narrow tubes that deliver water directly to the base of the plant (Photo 2).

Photo 2: Drip irrigation (a) Kimamba village (2b) Mbumi village
Source: Field study (February, 2017).

Intercropping is a multiple cropping practice involving growing two or more crops in proximity. The most common goal of intercropping is to produce greater yields on any given piece of land by making use of resources or ecological processes that would otherwise not be utilized by a single crop (Ouma, 2010). During FGDs, the researcher asked smallholder farmers about their understanding regarding crop intercropping, and the following is a summary of what one FGD revealed:

> "*Intercropping helps us to get more yields from the same piece of land, and it is easy to manage. Normally, we smallholder farmers practice intercropping because we possess small pieces of land.*"

Photo 1: Intercropping at Mkwatani village
Source: Field study Feb, 2017

Terracing is a piece of sloped plane that cut into a series of successively receding flat surfaces or platforms, which resemble steps, for purposes of decreasing both soil erosion and surface water runoff. They are commonly used on hilly or mountainous areas for effective farming (UNESCO, 2013).

Plate 4: **Terracing at Mbumi village**
Source: *Field study Feb, 2017*

Resistant-crop varieties are crops that are able to survive under unpleasant situations such as droughts, pests and diseases (Griffiths et al., 2000). Photo 5 shows an example of a drought-resistant crop (cassava), which is among the drought-resistant crop varieties grown in Mbumi village in the study district.

Photo 5: Cassava is an Example of Drought-resistant Crop
Source: Field study, February, 2017

Crop rotation is the practice of growing a series of dissimilar or different types of crops in the same area in sequenced seasons (Francis, 2003). It is done so that the farm soils are not used for only one set of nutrients (ibid.). Crop rotation increases organic matter in the soil, improves soil structure, reduces soil degradation and can result in higher yields that ensure greater farm profitability in the long-term (McCarthy et. al., 2011). In the studied villages, smallholder farmers practice crop rotation across all the six studied villages.

Crop Production Level from the Adopted and Practiced CSA

Table 9 presents general results on production level across the six (6) studied villages in Kilosa District. The findings show that 55 percent of the sampled households had medium-level crop production from the adopted CSA practices. Furthermore, 31 percent of the sampled households had high-level crop production, while 13 percent had low-level productivity from the adopted CSA practices.

Table 9: Crop Production Level from the Adopted Practiced CSA

Level of Productivities	Frequency	Percentage
High	31	31
Medium	55	55
Low	13	13

Source: Field study (February, 2017).

By comparing changes in production levels as stated by smallholder farmers before and after the adoption of CSA, the crop production data from the District Office shows that before the adoption of CSA, maize and paddy crop yields were between 3 and 8 bags, and 4 and 10 bags per acre, respectively. However, after the adoption of CSA, maize production yields increased from 3 to 8 eight bags per acre to 10–17 bags per acre; and paddy increased from 4–10 bags to 15–35 bags per acre (Kilosa District Office, 2017). Furthermore, the records from the District Office for the 2016/2017 season showed that general crop yields rose from 42 percent to 82 percent. Thus, such patterns reveal that CSA practices played a positive role in increasing crop production in the study area.

Contribution of CSA practices in Improving Household Food Security and Income (Adaptive Capacity)

The study further examined the extent to which the adoption of CSA practices had impacted household food security and incomes. Table 10 depicts that 6 percent of the total sampled household respondents reported that CSA practices had not led to any increase in food security. Nevertheless, 19 percent reported that CSA practices had increased food security a little; 50 percent reported that CSA practices had generally increased food security; while 25 percent reported that CSA practices had highly increased food security.

Table 10: Contribution of CSA in Enhancing Household Food Security and Income

Statement	Percentage Score			
	Not all	*Little*	*Somewhat*	*A lot*
Increased food security	6	19	50	25
Increased household income	1	32	44	23

Source: Household field survey (February, 2017).

Also, regarding household income, many of the sampled households ascertained that CSA had positively contributed to increased household incomes (Table 10).

Those who experienced some advancement/improvement in food security as a result of adopting CSA practices revealed that selling crops such as pigeon peas, sesame, cow peas, maize, paddy and vegetables helped them to have sufficient food; and also income to meet other household financial obligations.

From the chi-square and cross-tabulation in Table 11, there is no statistically significant relationship between the time taken in CSA engagement and the level of productivity as the chi-square = 11.417, and p-value = 0.924, which is greater than $\alpha = 0.05$.

Table 11: Relationship between the Respondents Time Taken in CSA Engagement and Productivity Level

Time taken for CSA engagement		Level of productivities			Total
		High	*Medium*	*Low*	
One year	Count	4	7	1	12
	Expected Count	3.8	6.7	1.6	12.0
Two years	Count	11	11	3	25
	Expected Count	7.8	13.9	3.3	25.0
Three years	Count	12	26	6	44
	Expected Count	13.5	23.9	5.6	43.0
Four years	Count	0	7	0	7
	Expected Count	2.2	3.9	.9	7.0
Five years	Count	3	2	2	7
	Expected Count	2.2	3.9	.9	7.0
6+	Count	2	2	1	5
	Expected Count	1.6	2.8	.7	5.0
Total	**Count**	**32**	**55**	**13**	**100**
	Expected Count	**31.0**	**55.0**	**13.0**	**100**

	Chi-Square Tests		Asymptotic Significance
	Value	**df**	**(2-sided)**
Pearson Chi-Square	11.417[a]	10	.326
Likelihood Ratio	13.839	10	.180
Linear-by-Linear Association	.700	1	.403
N of Valid Cases	99		

Note: [a] 12 cells (66.7%) have expected count less than 5. The minimum expected count is .66

Also, the expected counts from the cross-tabulation in Table 11 proved that the expected value and the actual count are not that different. Therefore, a person's long period or shorter period engagement in CSA has no relationship with him/her having higher or lower level of productivity.

Benefits Accrued as a Result of Adopting CSA Practices

The results in Table 12 show benefits gained due to the adoption of CSA practices as identified by the sampled households. Improved yields, reduced soil loss, increased soil moisture, and increased organic matter were the major benefits identified by the majority of the household respondents.

Table 12: Benefits Accrued as a Result of Adopting CSA Practices

Statement	Percentages Score				
	Strong agree	*Agree*	*Disagree*	*Strong Disagree*	*Undecided*
Reduced soil erosion	44	12	5	2	37
Increased organic matter	72	10	7	5	6
Improved yield	84	8	2	2	4
Save time and labour requirement	62	26	4	1	7
Increase soil moisture	61	13	10	2	14
Reduced input cost	28	21	16	14	21
Reduce soil lose	79	7	9	3	2
Provide favourable climate	76	11	1	0	12

Source: Household field survey February, 2017

Table 13 presents the relationship between CSA increasing soil moisture and the level of productivity. The observed chi-square and cross-tabulation shows that there is no statistically significant relationship between having increased soil moisture and productivity level: chi-square = 10.905; and *p*-value = 0.207, which is greater than α = 0.05. Also, the expected counts from the tabulation prove that the expected value and the actual count are not that different: thus, a person's benefit from CSA by being able to increase soil moisture does not translate into the person obtaining high or low productivity levels.

Table 13: Relationship Between Respondents who Reported Whether CSA had Increased Soil Moisture and the Level of Productivity

Increases of Soil Moisture		Level of Productivity			Total
		High	*Medium*	*Low*	
Strongly agree	Count	22	29	10	61
	Expected Count	18.8	33.3	7.9	60.0
Agree	Count	3	8	2	13
	Expected Count	4.1	7.2	1.7	13.0
Disagree	Count	3	7	0	10
	Expected Count	3.1	5.6	1.3	10.0
Strongly disagree	Count	2	0	0	2
	Expected Count	.6	1.1	.3	2.0
Undecided	Count	2	11	1	14
	Expected Count	4.4	7.8	1.8	14.0
Total	Count	32	55	13	100
	Expected Count	31.0	55.0	13.0	100

	Chi-Square Tests		Asymptotic Significance
	Value	*df*	(2-sided)
Pearson Chi-Square	10.905[a]	8	.207
Likelihood Ratio	12.697	8	.123
Linear-by-Linear Association	.001	1	.976
N of Valid Cases	99		

Note: a. 9 cells (60.0%) have expected count less than 5. The minimum expected count is .26

Source: household survey, 2017

Moreover, the study wanted to establish the relationship between engaging in CSA due to low costs involved, and growing crops using CSA practices. From the observed chi-square and cross-tabulation presented in Table 14, there is no statistically significant relationship between engaging in CSA due to the low cost criteria, and crop production employing using CSA practices: the chi-square = 0.275; and *p*-value = 0.600, which is greater than α = 0.05. In addition, the expected counts from the tabulation presented in Table 14 prove that the expected value and the actual count are not that different. Therefore, low costs of crop production is not the criteria adopted in choosing CSA practices in producing crops.

Table 14: Relationship between Engaging in CSA Due to Low Cost and Growing crops Using CSA

Grew crops using CSA		What criteria used to choose CSA practices 'Low cost'		Total
		Yes	*No*	
Yes	Count	9	36	45
	Expected Count	8.0	36.0	44.0
No	Count	9	46	55
	Expected Count	10.0	45.0	55.0
Total	**Count**	**18**	**82**	**100**

	Chi-Square Tests		Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
	Value	*df*			
Pearson Chi-Square	.275[a]	1	.600		
Continuity Correction	.069	1	.793		
Likelihood Ratio	.274	1	.601		
Fisher's Exact Test				.611	.395
Linear-by-Linear Association	.272	1	.602		
N of Valid Cases	100				

Note: [a] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.00; [b] Computed only for a 2×2 table

Challenges in Adopting CSA Practices

Table 15 indicates, participants' responses on the leading climate-related and non-climatic-related challenges in adopting CSA practices.

Table 15: Challenges Facing Smallholder Farmers in Adopting CSA Practices

Survey question	Frequency	Percentages
Challenges facing smallholder farmers in adopting CSA		
High cost of inputs	88	88
Lack of labour force	54	54
Unavailability of credit	91	91
Low price of CSA products	93	93
Pest and diseases	93	93
Lack of enough CSA knowledge	92	92
Shortened rains	96	96
Poor soil fertility	87	87
Droughts	92	92
Farmers-livestock keepers conflicts	92	92
Soil erosion	79	79
Lack of market access	93	93

Source: Household field survey February, 2017

The results in Table 15 indicate challenges facing smallholder farmers in adopting CSA practices as identified by respondents of the sampled smallholder famers in the study area. Shortened rains, lack of market access, low price of CSA products, farmers-livestock keepers' conflicts, droughts, lack of CSA knowledge, pest and diseases; as well as the unavailability of credit and farm renting: all these were identified by the majority of smallholder farmers as the major challenges in adopting CSA in the study area. Other cited challenges were weak transport and communications infrastructure, limited market information, **the** lack of enough knowledge on CSA **(**which was associated with the lack of technical and financial capacity to implement CSA practices**)**, **and** low prices of products (Table 15).

With reference to the mentioned challenges cited in Table 15, one key informant intimated:

> *"Our farmers are highly in need of adopting CSA because they have realized that CSA practices have more benefits, specifically in terms of ensuring food security, improving people's livelihoods by improving family incomes; as well as in tolerating impacts of climate change, particularly persistent drought. But the problem is that most farmers do not have their own land. They rent land from bigger landholders for a season. Thus, most farmers fail to put into practice some of the CSA practices such as drip irrigation because they have to return the land to the owners after the season*."

Furthermore, during FGDs, it was revealed:

> *"We farmers experience one major problem in adopting CSA. Most of the farmers rent farms and return them to owners after harvest. Thus, it is impossible to invest more on a farm that is not yours. But CSA is highly important since we have seen monetary gains for different households that employed CSA: their living standards have improved. Most importantly, CSA practices—such as the use of improved water management, and specifically drip irrigation—seems to be crucial in mitigating the impacts of climate change brought by drought and unpredictable rainfall, which are critical problems in our area. Through the use of drip irrigation people can cultivate, as well as plant, crops even during dry seasons; and be assured of harvests."*

The two statements quoted above reveals how the problem of rented land hinder intensive investment of CSA practices in the study area. Such kind of observations have been found to be the case elsewhere. Makate (2019) and Mugabe (2019), for example, asserted that a broad spread of the adoption of CSA is highly challenged by the lack of information and knowledge transmission, especially on the types of CSA practice that suit particular agro-ecological conditions. Also, Yusuphu (2014) and Mugabe (2019) postulate that the lack of requisite information can lead to the adoption of CSA practices that are expensive and unsuitable to a particular locality. Furthermore, Abegunde and colleagues (2019) proclaim that the adoption of CSA practices may be perceived as a risky investment because the initial investment is high and farmers are not assured of accessing credits and markets for their products. The costs and benefits of a particular CSA option also determine adoptions, which are, in turn, influenced by producers' ability to access input supply and output market chains (Yusuphu, 2014; Tucker et al., 2019). Furthermore, Conway and colleagues

(2019) reveal that the application of CSA requires appropriate equipment, skills and enough capital, which most smallholder farmers in developing countries lack. These are challenges that face smallholder farmers, and seem to be similar to those found in the study area, in regard to the adoption of climate-smart agriculture. Thus, there is a need for agricultural stakeholders to address these issues to enable smallholder farmers in developing countries adopt new CSA practices so as to enhance their adaptive capacity and improve food security in the continuously challenging phenomena of climate change and variability.

Opportunities Accessed by Smallholder Farmers Due to the Adoption of CSA Practices

Apart from the challenges experienced by smallholder farmers in adopting CSA in the study area, various CSA opportunities were mentioned in the study district. Among the identified opportunities include high demand for minimum water usage technologies such as drip irrigation, in which most smallholder farmers were interested and were eager to adopt since they realized this could sustain agricultural crop production. This was revealed during KIIs, which revealed the following:

> *"Most of smallholder farmers are highly motivated to adopt drip irrigation technologies since they believe that they can be used at any time, specifically during dry seasons and during periods of unpredictable rains."*

Furthermore, the adoption of CSA has brought about an increase of crop mills in the district. For example, according to the District Agricultural Officer, paddy and maize mills increased due to the increase in farm yields as a result of the adoption of CSA, particularly irrigation schemes, as well as the introduction of varieties of improved seeds of rice and maize.

Also, employment opportunities have increased due to the adoption of CSA, as narrated by respondents from one FGD discussion:

> *"The adoption of CSA, especially irrigation schemes, triggered by the availability of improved seeds, has influenced a good number of people—particularly the youths—to engage in agricultural crop production following the building, for example, of the Mvumi Irrigation scheme, which has enabled the availability of water supply in farms for paddy cultivation. This has led to many people, especially the youths, to be employed in agricultural crop production."*

In addition, the District Agricultural Officer disclosed:

> *"Employment opportunities have emerged in the district due to the establishment of agricultural crop mills, for example, for paddy and maize, which have employed a good number of people following an increase in crop yields as a result of the adoption of CSA. Also, agricultural extension officers have been employed, and are distributed at different levels in the district."*

An increase in demand for agricultural inputs such as improved seeds, pesticides and fertilizers for smallholder farmers has also provided opportunities to agro-dealers to trade in the study area.

The adoption of CSA practices has also increased household incomes, as revealed during FGDs with smallholder farmers:

> *"The adoption of CSA, to great extent, has improved our livelihoods since it has improved crop yields that has led to increases in household incomes. Thus, we have improved our living standards because we have managed to build good houses, access medical treatments, pay our children's school fees: for sure, our lives have changed compared to the previous time before the adoption of CSA."*

Concerning soil and water conservation, the District Agricultural Officer revealed:

"The use of terraces, particularly in slope areas through awareness strengthening on the adoption of CSA, has led to improvements of soil conservation for reduced soil erosion. Also, the adoption of CSA through the use of irrigation schemes, as well as drip irrigation for crop production, has resulted into water conservation through better ways of water management."

These opportunities that arose due the adoption of CSA are similar to those of found elsewhere. For instance, Tumwesigye et al., (2019) revealed various opportunities resulting from the adoption of CSA, which included climate change mitigation by reducing GHG emissions, improved crop production, increased household incomes for smallholder farmers, soil and water conservation, provision of employment opportunities to the youth, as well as women, and the enhancement of biodiversity conservation (ibid.). Also, Abegunde et al., (2019) revealed that CSA offers a triple-win opportunity, including food security, adaptation and mitigation. These studies further reveal that due to the potential of CSA to improve livelihoods, both national and international donor agencies have focused promoted CSA practices.

Conclusion

This article support the conclusion that the adoption of CSA practices such as the use of irrigation schemes, drip irrigation, application of improved seeds and the adoption of drought-resistant crop varieties contributes to enhancing adaptive capacity and improving food security to smallholder farmers amidst climate change and variability. In so doing, resultant opportunities—such as high demand for minimum water-use technologies such as drip irrigation and new opportunities on novel minimum water usage irrigation technologies—are established. Furthermore, there was an increase in crop processing mills in the district, specifically for paddy and maize; increase in the demand for agricultural inputs such as improved seeds, pesticides and fertilizers; and an increase in household incomes. CSA practices have also not only enhanced adaptive capacity and improved food security of the populace, but have also been a major means of improving soil and water conservation in the study areas.

However, there are challenges in adopting CSA practices that need to be addressed, and these include famers-livestock keepers' conflicts, problem of market accessibility, CSA knowledge dissemination and lastly, inaccessible credits to smallholder farmers. This article proposes that authorities at district and national levels put more emphasis on promoting the adoption of CSA in Tanzania so as to achieve the goal of ensuring food security in the country; as well as enhancing smallholder farmers' adaptive capacity to climate change and variability.

References

Abegunde, V.O., Sibanda, M. & Obi, A. (2019). The Dynamics of Climate Change Adaptation in Sub-Saharan Africa: A Review of Climate-Smart Agriculture among Small-Scale Farmers. *Climate*, 7(11): 132.

Alexander, S. (2019). What Climate-Smart Agriculture Means to Members of the Global Alliance for Climate-Smart Agriculture.

Boydell, E., Webb, J. & Sterrett, C. (2018). Using Climate and Disaster RISK Information to Build Resilience. What Are the New Challenges? *Advances in Space Research*, 62(7): 1639–1653.

CCAFS. (2014). *Climate-Smart Agriculture*: *Acting Locally, Informing Globally*-2014 Annual Report highlights. Copenhagen, Denmark.

CIAT, World Bank. 2017. Climate-Smart Agriculture in Tanzania. CSA Country Profiles for Africa Series. International Center for Tropical Agriculture (CIAT); World Bank, Washington, D.C. 25 p.

Conway, G., Badiane, O. & Glatzel, K. (2019). *Food for All in Africa*: *Sustainable Intensification for African Farmers*. Cornell University Press.

Davies, G. & Thornton, N. (2011). *Climate Change Financing and Aid Effectiveness*: *Tanzania case study*. http: //www.oecd.org/ dac/environment-development: site visited on 9/9/2016.

District Agricultural Sector Investment Project - (DASIP, 2016). Available at: http: //www.kilimo.go.tz/index.php/en/programmes/view/district-agricultural-sector-investment-project-dasip, accessed September 4, 2017.

Food and Agriculture Organization of the United Nations - (UNFAO, 2017). *Climate Smart Agriculture*: Retrieved 14th June 2017, From http: //www.fao.org/climate-smart-agriculture/en/.

UNFAO. (2013). *Climate-Smart Agriculture Sourcebook*. Rome.

Francis, C.A. (2003). Advances in the Design of Resource-Efficient Cropping Systems. *Journal of Crop Production*, 8: 15–32.

Griffiths, J.F., Miller, H., Suzuki, T., Lewontin, C. & Gelbart (eds). (2000). *Genetics and the Organism*: *Introduction. An Introduction to Genetic Analysis* (7th Ed.). New York: W. H. Freeman.

IPCC. (2014). *Climate Change* 2014: *Synthesis Report*. Contribution of Working Groups I. *II and III to the Fifth Assessment Report of the intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland*, 151.

Li, L., Thornton, P., Campbell, M.B., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P., Cattaneo, A., Garrity, D., Henry, K., Hottle, R., Jackson, L., Jarvis, A., Kossam, F., Man, W. & McCarthy, N. (2014). *Climate-smart Agriculture for Food Security*. Macmillan Publishers Limited: springer.

Makate, C. (2019). Effective Scaling of Climate Smart Agriculture Innovations in African Smallholder Agriculture: A Review of A, roaches, Policy and Institutional Strategy Needs. *Environmental Science & Policy*, 96: 37–51.

Mbilinyi, A., Ole Saibul, G. & Kazi, V. (2013). *Impact of Climate Change to Small Scale Farmers: Voices of Farmers in Village Communities in Tanzania*. Discussion Paper No. 47. Economic and Social Research Foundation, Dar es Salaam, Tanzania. 44,. 51.

Mccarthy, N., Li, er L. & Branca, G. (2011). *Climate Smart Agriculture*: *Smallholder Adoption and Implications for Climate Change Adaptation and Mitigation*. Working Paper No.4. Mitigation of Climate Change in Agriculture, Rome, Italy. 33,.

Mkambala, J.K. (2016). *Kilosa District Council Morogoro Region Tanzania*: *Climate Change Adaptation Plan for Maize Crop* 2016–2021. District Executive Director-Kilosa.

Mugabe, P.A. (2019). Assessment of Information on Successful Climate-Smart Agricultural Practices/Innovations in Tanzania. *Handbook of Climate Change Resilience*, 1–21.

Mung'ong'o, C. & Mwamfupe, D. (2003). *Poverty and Changing Livelihoods of Migrant Maasai Pastoralists in Morogoro and Kilosa Districts*. Mkuki na Nyota Publishers, Dar es Salaam, Tanzania. 49.

Nambiza, W. (2013). *Baseline Study for the Climate Change Agriculture and Poverty Alleviation Initiative*.[http: //www.tfcg.org/pdf/TFCG%2520CCAP% 2520Baseline% 2520 Survey% 2520Report%25202013%2520FINAL]. Site visited on 28/12/2016.

Ogada, M., Radeny, M,, Recha, J., Kimeli, P., Rao, J. & Solomon, D. (2018). Uptake and Impact of Climate-Smart Agriculture Technologies and Innovations in East Africa.

Rosenstock, T. S., Lamanna, C., Chesterman, S., Bell, P., Arslan, A., Richards, M. & Corner-Dolloff, C. (2016). The Scientific Basis of Climate-Smart Agriculture: A Systematic Review Protocol.

Schaafsma, M. & Bell, A.R. (2018). *Scaling up Climate-smart Agriculture.*

Shemsanga, C., Omambia, A. N. & Yansheng, G. (2010). The Cost of Climate Change in Tanzania: Impacts and Adaptations. *Journal of American Science,* 6(3): 182–196.

Tucker, T., Hobbs, P. & Chindori-Chininga, K.Z. (2019). Scoping Study Report for Episcopal Relief and Development Food Security Programs in Zimbabwe and Tanzania.

Tumwesigye, W., Aschalew, A., Wilber, W., Atwongyire, D., Nagawa, G.M. & Ndizihiwe, D. (2019). Climate Smart Agriculture for Improving Crop Production and Biodiversity Conservation: Opportunities and Challenges in the 21st Century-A Narrative Review. *Journal of Water Resources and Ocean Science*, 8(5): 56–62.

UNESCO. (2013). *World Heritage List.* Retrieved on 2017/04/23.

United Republic of Tanzania (URT). (2007). *National Adaptation Programme of Action* (*NAPA*). Division.

United Republic of Tanzania (URT). (2015). *The State of National Economy in the Year 2015.*

Wiebe, K., Robinson, S. & Cattaneo, A. (2019). Climate Change, Agriculture and Food Security: Impacts and the Potential for Adaptation and Mitigation. In *Sustainable Food and Agriculture* (pp. 55–74). Academic Press.

Yusuph, A. (2014). *Economic Analysis of Climate Smart Agriculture Practices among Smallholder Farmers Kiolsa District*. Thesis, Degree of Master of Science in Environmental and Natural Resource Economics of Sokoine University of Agriculture, Morogoro, Tanzania.