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The Effectiveness of Adaptation Strategies to Climate Change and Variability in Enhancing Rural Smallholder Farmers' Food Security in Mvomero District, Tanzania

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Abstract

This study seeks to provide an understanding of the effectiveness of adaptation strategies to climate change and variability in enhancing food security of rural smallholder farmers in Mvomero District. Food availability, measured by surplus food production, was the indicator of food security. Simple random sampling was used to get 373 respondents, while purposive sampling was used to get 38 key informants and 56 focus group participants. Household questionnaire interviews, in-depth interviews, focus group discussions, and a review of document were used to collect data. Descriptive and inferential statistics were used to analyse the quantitative data, while the qualitative data were analysed through content analysis. The results revealed that a majority of the respondents (27%) frequently practised intercropping as an adaptation strategy to climate change and variability. Others grew drought-resistant crops and early-maturing crop varieties, mixed farming, irrigation farming, and being involved in off-farm activities. Also, the majority (53%) had no surplus food production, indicating that they were food insecure. The results further revealed that the cultivation of drought-resistant crops and intercropping strategies had statistically significant ($p<0.05$) negative relationship with surplus food production, suggesting that respondents who were rarely, or not practising these strategies, were less likely to have surplus food production compared to respondents who were frequently practising them. Thus, growing of drought-resistant crops and intercropping are effective strategies in improving food security; suggesting that these strategies should be promoted to improve food security of rural smallholder farmers in Mvomero district.

Keywords: *adaptation strategies, climate change and variability, food security, smallholder farmers*

1. Introduction

Currently, climate change and variability are the global environmental challenges affecting the livelihoods of most people in the world (Thakur & Bajagain, 2019). Statistically, from 2015 to 2019 the global average land surface air temperature increased to 1.7^{0}C above that of the pre-industrial period (WMO,

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2019). Precipitation is projected to be high in mid- and high latitudes of the northern hemisphere continents, but low in subtropics (IPCC, 2018). Climate change and variability have posed tremendous impacts on ecosystems, infrastructure, assets and livelihood strategies of people (Abaje et al., 2014). In Central America, Harvey et al. (2018) indicate that about 57% of smallholder farmers reported their agricultural system to have been affected by droughts, 52% by extreme rainfall, 32% by hurricanes and 12% by floods. In Asia, Sajjad et al. (2017) indicated that the increase of temperature and irregularity of rainfall decreased wheat production from 25.979m tonnes in 2013/2014, to 25.478m tonnes in 2014/2015 production periods.

In Africa—and Sub-Saharan region, in particular—climate change and variability have been noticed by the majority of people as a change in rain onset, duration of rainfall, frequencies of dry spells and rainfall intensity (UNDP, 2018). People have opted for various farming and non-farming strategies so as to improve their livelihoods (Asare-nuamah & Botchway, 2019). The farming strategies practised include—but are not limited to—mixed cropping, intercropping, mixed farming, irrigation farming, growing drought-resistant varieties, growing early-maturing crop varieties, shifting planting calendar, and other strategies such as cover cropping (Andrew & Galinoma, 2017).

In Tanzania, studies—such as Kulyakwave et al. (2019) and Elia (2017)—have shown that most people perceived climate change and variability in terms of decrease of rainfall, and increase of temperature; and they have been responding to these changes through various farming and non-farming adaptation strategies in enhancing food security. Although most rural smallholder farmers in Tanzania have been using various adaptation strategies to climate change and variability—such as intercropping, mixed farming, irrigation farming, growing drought-resistant crop varieties, using early-maturing crop varieties, and other strategies—they still experience poor crop yields and loss of income (Kihupi et al., 2015). Limited knowledge and information on which adaptation strategies are effective in enhancing food security has remained a challenge. This study, therefore, intended to add knowledge on the effectiveness of adaptation strategies to climate change and variability in enhancing food security.

Furthermore, a number of studies (Kathleen, 2018; Mousavi & Eskandari, 2014 & Roco et al., 2017) have been done on the effectiveness of adaptation strategies to climate change and variability in enhancing food security. Most of these studies, however, have focused on Asia (Roco et al., 2017; Shahbaz et al., 2017; Ali & Erenstein, 2017); and only a few on Africa (Adebayo et al., 2018; Amondo & Simtowe, 2019; Tefera & Cho, 2017). Generally, in Tanzania, there are few studies (Kazoka, 2013) that have focused on evaluating the effectiveness of adaptation strategies to climate change and variability in enhancing food security of rural smallholder farmers. Most of these studies (Mkonda & Xinhua, 2018; Nyankweli et al., 2016; Mtupile & Liwenga, 2017; Sanga et al., 2015), however, have been on climate change and variability impacts; and on adaptation strategies. Therefore, this study aimed to fill this research gap by evaluating the effectiveness of adaptation strategies to climate change and variability in enhancing the food security of smallholder farmers.

This paper is organized in three sections. Subsequent to the introductory section one, section two covers the description of the study area and the methodologies used in the study. Section three presents the results and discussions on the adaptation strategies to climate change and variability; and their effectiveness in enhancing food security of smallholder farmers. Section four draws conclusion and provides recommendations of the study.

2. Context and Methods

2.1 *The Study Area*

The study was carried out in Mvomero district, and specifically in Melela and Magali villages in Melela ward, Mlali and Vitonga villages in Mlali ward, and Doma and Maharaka villages in Doma ward (Figure 1). Mvomero district was deliberately selected because, compared to other districts in Morogoro region, it is a semi-arid area characterized by drought and unpredictable rainfall that affect much the production of food crops. The three wards—Melela, Mlali and Doma—were purposefully selected because, unlike other wards, they have rural smallholder farmers with no irrigation infrastructure, and thus depend solely on rain-fed agriculture. In other wards—e.g., Mtibwa—both smallholder and large-scale farmers exist, with some owning sugar factories; and hence they are not affected much by climate change and variability as they have enough capital for adaptation. Out of the selected three wards, six villages—Melela, Magali, Mlali, Vitonga, Doma and Maharaka—were purposefully selected since most of the smallholder farmers in these villages were accessible, and showed cooperation and interest in the research topic.

Mvomero district is located between latitudes 05^{o} 80' and 7^{o} 40' south of the Equator, and between longitudes 37^{o} 20' and 38^{o} 05' east of Greenwich Meridian (Mkonda, 2014). The district has a total area of 7,325 square kilometres (URT, 2015). It is bounded by Kilosa district in the west, and by Morogoro urban and Morogoro district in the south. In terms of climate, the district experiences a bimodal rain pattern; with short rains falling in October to December, and long rains in March to May (URT, 2015). The average annual rainfall ranges between 700mm in the lowland areas, to 2300mm in high altitudes and adjacent areas (ibid.). The temperature ranges between 18^{o}C and 30^{o}C (ibid.).

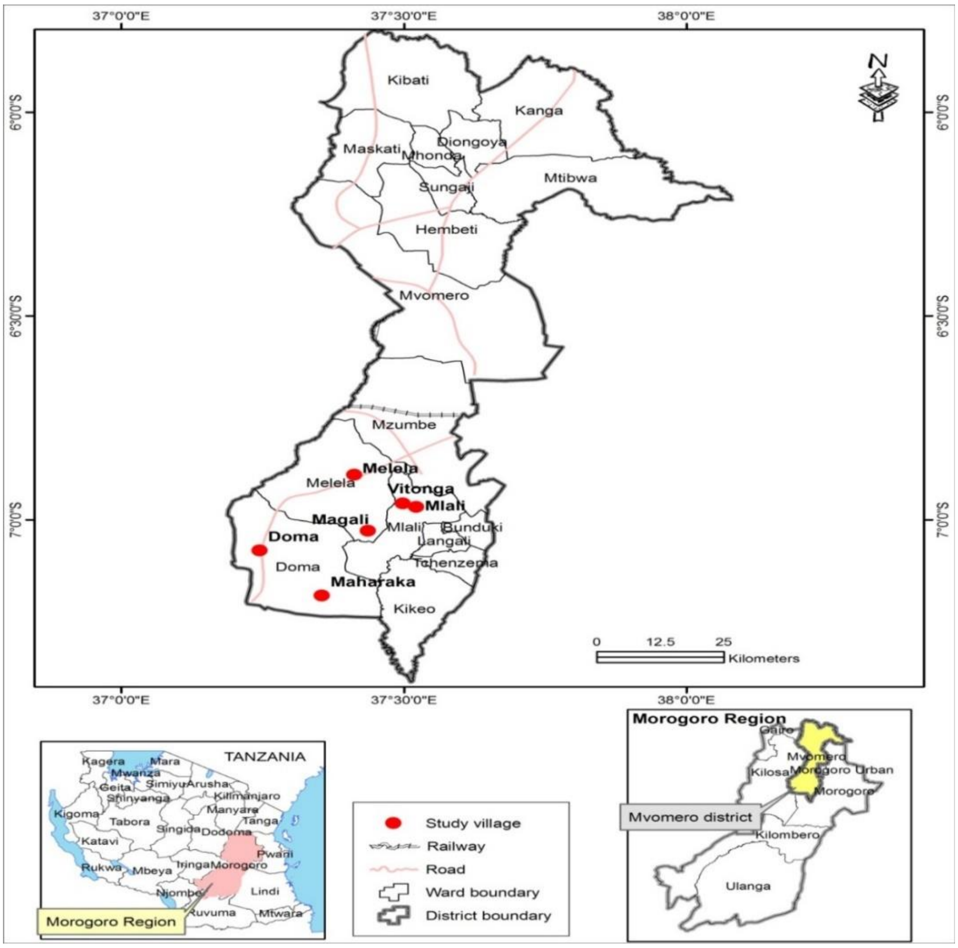

Figure 1: ***Location of the Study Area***

Source: GIS Unit, Institute of Resource Assessment, University of Dar es Salaam, 2018

2.2 Data Collection and Analysis

Both primary and secondary data were collected. Smallholder rural farmers, government officials, institutional representatives and other stakeholders were the sources of primary data. Published and unpublished documents—such as books, journal articles, dissertations and theses—collected from various libraries and the Internet were the sources of secondary data. The methods used to collect primary data included in-depth interviews of key informants, focus group discussions (FGDs) and household questionnaire interviews. The total sample size for the study was 373 respondents, which was determined through the Yamane (1967) formula cited in Israel (2003), and given as: $n = \frac{N}{1+N\,(e)^2}$; where n = sample size, N= population size, and e = the level of precision (5%).

$$\text{Therefore, } n = \frac{5{,}657}{1 + 5{,}657(0.05)^2}$$

$$n = \frac{5{,}657}{1{+}5{,}657(0.0025)} = 373 \text{ respondents}$$

Thus, the sample size was 373 respondents (Table 1). The proportional samples for the study villages *i* were obtained through the proportional allocation formula (Kothari, 2004), given as:

$$n.\ P_i$$

Where n represents the total sample size, and P_i represents the proportion of population (households) included in village i.

Thus, for example, the sample size for N_1 (Doma) = 373.1293/5657 = 85. The same was done for all villages. Table 1 presents the sample size obtained for each study village.

Table 1: Population and Sample Size for Questionnaire Survey

Wards	Villages	Population	Households	Sample ($n.\ P_i$)	Total (%)
Doma	Doma	4744	1293	85	22.8
	Maharaka	3290	1025	68	18.2
Melela	Melela	6375	860	57	15.3
	Magali	3470	690	45	12.1
Mlali	Mlali	6230	1479	98	26.3
	Vitonga	3383	310	20	5.3
Total		**27, 492**	**5, 657**	**373**	**100**

Source: National Bureau of Statistics, 2013

As aforementioned, purposive sampling was used in selecting three (3) wards out of the 17 wards in Mvomero district. From each ward two villages were purposively selected to get six villages for the study. The purposive sampling technique was also used to get a sample of 38 key informants for in-depth interviews, and 56 members for the FGDs.

The qualitative data that were collected through in-depth interviews of key informants and focus group discussions were analysed using content analysis. Through content analysis codes, themes or contents from FGDs and interview transcripts were created. Quantitative data collected through the household questionnaire interviews were entered into a computer for processing and analysis through the IBM Statistical Product and Service Solutions (SPSS) software, Version 20.0. Both descriptive statistics and a logistic regression model were used to analyse the quantitative data. The binary logistic regression model was used to model the relationship between adaptation strategies and food availability, measured by surplus food production. The equation for the model was defined as:

$$Y = \beta_0 + \beta_1 (DRC) + \beta_2 (IF) + \beta_3 (IS) + \beta_4 (EMV) + \beta_5 (MF) + \beta_6 (OFS) + \beta_7 (OAS) + \ldots\ldots\ldots\ldots\ \beta_Z$$

Where Y = surplus food production; β_0 = constant; β_1-β_z = coefficient of the explanatory variables; *DRC* = growing drought-resistant crops; *IF* = irrigation farming; *IS* = intercropping strategy; *EMV* = early-maturing crop varieties; *MF* = mixed farming; *OFS* = off-farming strategies; and *OAS* = other adaptation strategies.

In this model, surplus food production was the dependent variable (Y) with two categorical possible outcomes; such that $y = 0$ when rural smallholder farmers have no surplus food production, and $Y = 1$ when rural smallholder farmers have surplus food production. The independent variables of the model were the various adaptation strategies (Table 2). In addition, all of the predictor variables consisted of categorical variables with 2 levels: rarely, or not practised (coded 0); and frequently practised (coded 1). The frequently practised category was used as a reference category in the comparison with the first mentioned category.

Table 2: Independent Variables in the Binary Logistic Regression Model

Independent Variable	Description and/or Coding
Drought-resistant crops	0 = Rarely, or not practiced, 1 = Frequently practiced
Irrigation farming	0 = Rarely, or not practiced, 1 = Frequently practiced
Intercropping strategy	0 = Rarely, or not practiced, 1 = Frequently practiced
Early-maturing crop varieties	0 = Rarely, or not practiced, 1 = Frequently practiced
Mixed farming	0 = Rarely, or not practiced, 1 = Frequently practiced
Off-farming strategies	0 = Rarely, or not practiced, 1 = Frequently practiced
Other adaptation strategies	0 = Rarely, or not practiced, 1 = Frequently practiced

Source: Field data, 2018

3. Results and Discussion

3.1 *Adaptation Strategies to Climate Change and Variability in Relation to Food Crops Grown*

In understanding the types of food crops grown, respondents were given a list of various food crops and asked to identify all crops grown. The results (Table 3) revealed that most of the respondents grew maize, cassava, cowpeas, and pigeon peas. The remaining few respondents grew rice, beans, tomatoes, sorghum, sweet potatoes, and other food crops. This implies that maize, cassava, cowpeas, and pigeon peas were the most important food crops in the study villages compared to other food crops.

Table 3: Percentages of Respondents Who Produce Food Crops

Food Crops Grown	Respondents (%)		Total (%)
	Yes	*No*	
Maize	61	39	100
Rice	32	68	100
Beans	49	51	100
Cassava	52	48	100
Tomatoes	35	65	100
Sorghum	39	61	100
Cowpeas	53	47	100
Pigeon peas	58	42	100
Sweet potatoes	33	67	100
Others food crops	32	68	100

Source: Field data, 2018

Also, the respondents were given a list of various adaptation strategies and asked to identify one of the strategies frequently practiced in response to climate change and variability. The overall results (Table 4) revealed that most of the respondents were frequently practising intercropping. Some of the respondents were engaged in the growing of drought-resistant crops, growing of early-maturing crop varieties, mixed farming, irrigation farming, off-farming activities, and other adaptation strategies.

Table 4: Percentages of Respondents Practising Farming and Non-Farming Adaptation Strategies to Climate Change and Variability

Adaptation Strategies Frequently Practiced	Respondents (%)
Drought-resistant crops	89 (24%)
Irrigation farming	18 (5%)
Intercropping	101 (27%)
Early-maturing crop varieties	68 (18%)
Mixed farming	38 (10%)
Off-farming activities	28 (8%)
Other strategies	31 (8%)
Total	373 (100%)

Source: Field data, 2018

3.1.1 Intercropping

The majority of the respondents were frequently practising the intercropping strategy as a response to climate change and variability (Table 4). The results from in-depth interviews of key informants indicate that most of the respondents were growing more than one crop on the same piece of land at the same time. For example, they were growing maize with beans, maize with pumpkins, maize with pigeon peas, maize with cowpeas, and other intercropped crops. The results from FGDs further indicate that intercropping had multiple benefits to users. Some of the benefits include an effective use of land, reduction in fertilizer use, reduction in pests and diseases, weed suppression, and increase in multiple crop yields. These findings concur with those of Shisanya and Mafongoya (2016), who found that most smallholder farmers in uMzinyathi District of Kwazulu-Natal, South Africa, were practising intercropping and other adaptation strategies against the impacts of climate change and variability.

3.1.2 Drought-resistant Crops

The results revealed that about 24% of the respondents were frequently growing drought-resistant crops against climate change and variability (Table 4). These results were supported by those from in-depth interviews of key informants: that most farmers were growing drought-resistant crops such as millet, cassava, cowpeas, pigeon peas, sunflower, etc. As explained by the respondents, these crops were able to sustain dry conditions, and were frequently cultivated for food; with the surplus being sold to earn money to meet other family needs. These results concur with those of Ogunbiyi and Olajide (2017) who reported that most farmers in Kwara State, Nigeria, were growing drought-resistant crops as an adaptation strategy to climate change and variability. Fisher et al. (2015) also reported that farmers in sub-Saharan African countries—such as Ethiopia, Zambia and Zimbabwe—were growing drought-tolerant maize varieties to adopt for climate change and variability.

3.1.3 Early-maturing Crop Varieties

The results indicate that about 18% of the respondents were frequently cultivating early-maturing crop varieties. The results from in-depth interviews of key informants indicated that some of the early-maturing varieties grown were maize varieties, beans, cassava, and rice. According to the key informants, these varieties were grown because they matured early before the onset of the dry season, and they had high yields. These results are in line with those of Mango et al. (2017), who found that growing early-maturing crop varieties was practiced by the majority farmers in Southern Africa as an adaptation strategy to climate change and variability to improve food security. Similar findings were reported by Lemessa et al. (2019): that most smallholder farmers in Eastern Ethiopia adopted the early-maturing potato varieties against climate change and variability.

3.1.4 Mixed Farming

Also, the results indicate that about 10% of the respondents were frequently practising mixed farming (Table 4). These results concur with those from in-depth interviews of key informants and FGDs: that mixed farming was practised by smallholder farmers in the study villages. Through mixed farming smallholder farmers were growing food crops simultaneously with poultry or livestock farming. Mixed farming ensured the availability of food and income because, wherever there was a failure in crop farming, farmers survived through selling livestock or poultry products to fulfil family needs. One of the participants of a FGD in Doma village said:

> *Mixed farming is also practised in this village. This strategy has various advantages to farmers; and one of these is that during crop failure farmers survive through selling animal products to purchase food* (Female farmer, 52 years old in Doma village).

The above quotation reveal that smallholder farmers in the study villages were growing food crops together with rearing of animals as a strategy against climate change and variability, and this guaranteed adopters with availability of food. These results corroborate those of Mudashiru et al. (2021), who found that 90% of farmers in Katsina State, Nigeria, were practising mixed farming adaptation strategy to climate change and variability. Thornton and Herrero (2015) reported also that mixed farming was one of the prominent farming adaptation strategies practised in sub-Saharan African countries.

3.1.5 Irrigation Farming

Only a very few of the respondents (5%) reported to be frequently practising irrigation farming. These results do not agree with those of Tefera and Cho (2017), who found that irrigation farming was practised by a large number of smallholder farmers in Oromiya region, Ethiopia. Roco et al. (2017) also found that the majority of smallholder farmers in central Chile were practising irrigation farming as an adaptation measure against climate change and variability. The difference in the results could be explained by the limited irrigation infrastructure in the study villages compared to those in Oromiya region, Ethiopia; and central Chile. The results from in-depth interviews revealed that there were no irrigation infrastructure in the study villages. Also, even the small-scale irrigation farming practised in the study villages experienced shortages of water. This practice depended on collecting seasonal water in ponds or ground wells mainly for seasonal cultivation of vegetables. One of the key informants said:

> *In fact we have a challenge regarding access to water for irrigation farming. My experience in this environment is that, irrigation farming is the best solution to solve the problems of drought and variability of rainfall. There are a few of us who try to practise irrigation farming but we end up with no success in terms of improvement of food and increase of income. We keep on suggesting that the government and other people interested in promoting our farming in this district to think about irrigation infrastructure* (Village Chairperson, 48 years old in Maharaka village).

The above quotation suggests that while irrigation farming may be an important adaptation strategy to climate change and variability, farmers are constrained by the shortage of water and the lack of irrigation infrastructure. This explains why only a few farmers are practising it.

3.1.6 Off-farming Strategies

About 8% of the respondents reported to be frequently practising off-farm adaptation strategies to adapt to climate change and variability (Table 4). The results from interviews with key informants and FGDs indicate that off-farming strategies employed in the study villages were petty trade, charcoal making and selling, being employed as night guards, and engaging in daily-pay jobs. These results concur with those of Weldegebrial et al. (2020), who found that some smallholder farmers were engaging in off-farm activities to adopt to climate change and variability in their localities. Also, Mburu et al. (2015) reported similar findings: that most smallholder farmers in Yatta district, Kenya, adapted to climate change and variability through off-farm activities such as charcoal burning, sand harvesting, and hunting.

3.1.7 Other Strategies

About 8% of the respondents were frequently practising other adaptation strategies, including the application of fertilizers, application of manure, cover cropping, and change of planting dates. These strategies corroborate those of a study by Belay et al. (2017), who reported that smallholder farmers in the Central Rift Valley, Ethiopia, were practising crop diversification, planting dates adjustment, and other strategies to adopt to climate change and variability. Also, Okpe (2015) reported that most farmers in Makurdi, Nigeria, responded to climate change and variability through the use of chemical fertilizers, planting of cover crops, and the change of planting dates.

3.2 Effectiveness of Adaptation Strategies in Enhancing Food Security

The effectiveness of adaptation strategies in enhancing food security was assessed using one indicator: food availability, which was measured by surplus food production. The results reveal that about 53% of the respondents had no surplus food production, while 47% had surplus food production. These results may suggest that most rural smallholder farmers in the study villages were more likely to be food insecure. When asked to evaluate the effectiveness of the adaptation strategies they were practising in improving surplus food production, most of the respondents enumerated the growing of drought-resistant crops, intercropping, and mixed farming as the effective strategies in improving surplus food production (Table 5). These results suggest that these strategies enabled farmers to produce more food for their own consumption, and a surplus to sell and earn money for other uses.

The majority of the respondents (61%) appraised the cultivation of drought-resistant crops as an effective adaptation strategy in improving surplus food production (Table 5). Only 39% of the respondents said these crops were ineffective in improving surplus food production. Additionally, results from in-depth interviews of key informants, together with FGDs revealed that the growing of drought-resistant crops was effective in ensuring surplus food production. This means farmers who were cultivating drought-resistant crops—such as pigeon peas, cowpeas, and other crops—produced more food that was consumed, and a surplus that was sold for money that supported access to other food varieties not produced.

Table 5: Percentages of Respondents Evaluated the Effectiveness of Adaptation Strategies in Surplus Food Production

Adaptation Strategies	Effectiveness		Total (%)
	Effective (%)	*Ineffective (%)*	
Drought-resistant crops	61	39	100
Irrigation farming	33	67	100
Intercropping	52	48	100
Early-maturing crop varieties	44	56	100
Mixed farming	59	41	100
Other strategies	47	53	100

Source: Field data, 2018

The results from the binary logistic regression model reveal that growing drought-resistant crops had a statistically significant ($p < 0.05$) negative relationship with surplus food production (Table 6). This means that respondents who were rarely, or not growing drought-resistant crops were less likely to have surplus food production compared to those who were frequently doing this.

Table 6: The Relationship between Adaptation Strategies and Surplus Food Production

	B	S.E	Wald	df	Sig.	Exp(B)
DRC(1)	-.908**	.437	4.310	1	.038	.403
IF(1)	.104	.613	.029	1	.866	1.109
IS(1)	-.939**	.430	4.760	1	.029	.391
EMV(1)	1.156**	.494	5.474	1	.019	3.176
MF(1)	-.194	.495	.154	1	.695	.824
OAS(1)	1.598**	.654	5.965	1	.015	4.941
Constant	-1.164	2.091	.310	1	.578	.312

Note: **Significant at 5%

Key: DRC = Drought-Resistant Crops; IF = Irrigation Farming; IS = Intercropping Strategy; EMV = Early-maturing Crop Varieties; MF = Mixed Farming; OAS = Other Adaptation Strategies.

Source: Field data, 2018.

These results suggest that the growing of drought-resistant crops was an effective strategy in improving surplus food production. Therefore, this strategy was more likely to be effective in enhancing food security, particularly food availability for smallholder farmers in the study villages. Similar observations were reported by Amondo and Simtowe (2019): that most of the smallholder farmers in Zambia who were growing drought-tolerant maize varieties as an adaptation measure against climate change and variability had surplus food production that ensured food availability, as well as food security. Lunduka et al. (2017) also reported that rural smallholder farmers in Eastern Zimbabwe, who were growing drought-tolerant maize varieties, had surplus food production, compared to those who did not grow these varieties

The results in Table 5 further reveal that irrigation farming was an ineffective strategy in improving surplus food production as mentioned by 67% of the respondents. These results may suggest that irrigation farming enabled adopters to produce food for consumption only. These results corroborate those from in-depth interviews, where key informants said irrigation farming was not effective in their villages. Moreover, it could only be effective in improving surplus food production if farmers had access to irrigation infrastructure and technology. Irrigation farming had a positive but not statistically significant ($p < 0.05$) relationship with surplus food production (Table 6). The positive coefficient suggests that respondents who were rarely, or not practising irrigation farming were more likely to have surplus food production than those who were frequently practising it. This implies that irrigation farming was less likely to be an effective strategy in improving surplus food production of smallholder farmers, and was thus less likely to improve food security of smallholder farmers in the study villages.

The preceding results agree with those of Tan (2013), who reported that irrigation farming in Northern Philippines was a less effective strategy in improving surplus food production and, therefore, was less likely to improve the food security of rural smallholder farmers in the study area. On the other hand, these results differ with those of Roco et al. (2017) who reported that irrigation farming in Central Chile improved food production and food security of those who were practising it, compared to those who did not practise it. The availability of irrigation infrastructure, access to information, and knowledge on irrigation farming could have made the strategy effective in enhancing food security and income of adopters in Central Chile, compared to those in the study villages in Mvomero district.

Intercropping was also reported by many of the respondents to be an effective adaptation strategy in improving surplus food production (Table 5). Through intercropping farmers were able to produce enough food for their consumption, while the surplus was sold to get money for other needs. The results from FGDs also supported this view as many participants reported that intercropping two or more crops—such as maize with beans, or maize with cowpeas or pumpkins—enhanced surplus food production. Further analysis of the results showed a statistically significant ($p < 0.05$) negative correlation with surplus food production, meaning that respondents who were rarely, or not practising intercropping were less likely to have surplus food production than those who were frequently practising intercropping (Table 6). These findings suggest that intercropping was more likely to be an effective strategy in enhancing surplus food production and improving food security of the adopters. These results correspond to those of Nassary et al. (2020) who found that intercropping common beans with maize, as an adaptation strategy against climate change and variability, increased yields and surplus production in Southern Highlands, Tanzania; hence, the strategy improved food security of smallholder farmers. Jensen (2017) reported further that intercropping of cereals and grain legumes against climate change and variability improved surplus food production, thus improving food security of rural farmers in tropical regions.

Again, the results in Table 5 reveal that planting early-maturing crop varieties was considered by most of the respondents to be ineffective in enhancing surplus food production. Further analysis of the results, however, show that the adoption of early-maturing crop varieties had a statistically significant ($p < 0.05$) positive relationship with surplus food production (Table 6). This implies that the respondents who were rarely, or not adopting early-maturing crop varieties were more likely to have surplus food production than respondents who were frequently practising it. These findings suggest that adopting early-maturing crop varieties was less likely to be an effective strategy in improving surplus food production. This means that the strategy was generally less likely to be effective in improving food availability, and hence the food security of smallholder farmers. These results are different from those of Manda et al. (2015), who reported that the adoption of early-maturing maize varieties improved surplus food production, and most of the adopters were more likely to be food secure. The differences in the results could be due to the fact that farmers in the study villages had poor selection of quality early-maturing seeds. Also, ignorance on proper planting, weeding, pests, and diseases control could have contributed to the ineffectiveness of early-maturing crop varieties as an adaptation strategy against climate change and variability.

Mixed farming was also considered by many of the respondents as an effective adaptation strategy in enhancing surplus food production (Table 5). These results were supported by those from in-depth interviews of key informants. The majority of the key informants (70%) reported that farmers had surplus food production under mixed farming due to the fact that crop farming may be supported by capital from livestock or vice-versa. Mixed farming enabled surplus food production in the sense that crop farming gave feeds to animals, and animals provided fertilizers to support crops. The relationship between mixed farming and surplus food production was found to be negative, and not statistically significant ($p < 0.05$) (Table 6), meaning that the respondents who were rarely, or not practising mixed farming were less likely to have surplus food production compared to those who were frequently practising the strategy. This suggests that mixed farming was more likely to be an effective strategy in improving surplus food production of rural smallholder farmers in the study villages and, hence, providing them food security. These results agree with those of Shahbaz et al. (2017), who found that mixed farming was an effective strategy in enhancing food security of adopters in Faisalabad Punjab, Pakistan. Mudashiru et al. (2021) also found that mixed farming was one of the climate smart agricultural practises that improved food production and food security of most adopters in Katsina State, Nigeria.

The study results (Table 5) further revealed that many respondents considered other adaptation strategies—such as changing the planting calendar, mixed cropping, application of pesticides and other chemicals in farming—to be ineffective in improving surplus food production. There was, however, a statistically significant ($p < 0.05$) positive relationship between these strategies and surplus food production (Table 6). This implies that the respondents who were rarely, or not practising other adaptation strategies were more likely to have surplus food production than those who were frequently practising other strategies. These results suggest that other adaptation strategies were less likely to be effective in improving surplus food production and, therefore, were less likely to be effective in improving food availability and food security of rural smallholder farmers in the study villages. These results, however, do not agree with those of Uttam and Hoang (2018), who reported that other adaptation strategies to climate change and variability—such as changing of the planting calendar and application of fertilizers—were effective in improving food security of adopters in Nepal. On the other hand, Ali et al. (2021) found that the application of fertilizers and other agricultural chemicals was effective in increasing crop yields and food security of adopters in Rajshahi district in Bangladesh. Inadequate farm capital and the lack of information and knowledge on proper use of fertilizers and other chemicals against climate change and variability could have contributed to the ineffectiveness of these strategies in the study villages in Mvomero district.

4. Conclusion and Recommendations

Mvomero district has been experiencing changing climate over time with increasing temperatures and unpredictable rainfall. In response to these changes, farmers have been practising the growing of drought-resistant crops and early-maturing crop varieties, irrigation farming, intercropping, mixed farming, off-farm activities, and other adaptation strategies such as changing of the planting calendar and cover cropping. However, a majority of the farmers were found to frequently practise intercropping as an adaptation strategy to climate change and variability. Despite these adaptation strategies, the majority of the farmers were found to be food-insecure as they could not produce surplus food. Nonetheless, growing of drought-resistant crops and intercropping were found to be the more likely effective strategies in enhancing surplus food production. Therefore, these strategies can be considered to be effective in enhancing food availability and, thus, can enhance food security of adopters. For this reason, it is recommended that the growing of drought-resistant crops and intercropping should be promoted in the study villages to improve food security. These strategies could be promoted by ensuring that farmers have access to information and training about their effectiveness in enhancing food security. Also, these strategies could be promoted through providing farmers with subsidies; including fertilizers, agricultural equipment, seeds and credit.

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