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Determinants of Farmers' Choice of Coping Strategies to Climate Variability and Change in Manyoni District, Singida Region, Tanzania

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Abstract: *Climate variability and change (CV & C) poses a threat to the sustainability of food production among small-scale farmers in rural Tanzania that are dependent on rain-fed agriculture. Understanding farmers' coping to CV & C and the determinants of their coping decision is crucial in designing realistic strategies and policies for agriculture development. Therefore, this study investigated coping strategies practiced by small-scale farmers and factors that influenced coping decisions in Manyoni District. A random sampling technique and household survey method was used to gather cross-sectional data from 330 small-scale farmers selected from 6 wards. Out of 8 coping strategies identified by small-scale farmers, the four main coping strategies were subsequently adopted and used included; selling of livestock, off-farm employment, decreasing meal consumption and supplementing livestock feeds. The findings from Multivariate Probit Model showed some households' characteristics that influenced the choice of coping strategies were; the age of household head, household size, farm size, farming experience, technology uses, annual income, extension services, livestock ownership, and shift in rain season. The study concludes that the adoption of coping strategies is important and inevitable. Economic activities diversification through livestock keeping and off-farm employment is the key factor to minimize the impact of CV & C. Extension services is the significant determinant factor for the adoption of coping strategies and survival of small-scale farmers. The study recommends that the government and Non-governmental organizations should invest in climate-resilient programs and formulate policies that will focus on addressing challenges facing small-scale farmers in the course of adopting coping strategies. Government policies and investment must be geared towards the support of education on coping strategies, diversification in economic activities through off-farm employment, livestock keeping, and the use of technology. The government should formulate policies on extension services to ensure deployment of extension agents in every villages.*

Keywords: *Coping strategies, climate variability, climate change, farmers' choice, small-scale farmers*

1. Background Information

Climate variability and change (CV & C) is a reality and its impact on agriculture productivity and other social-economic activities cannot be underestimated. Universal warming due to greenhouse gases can alter the variability of climate. The CV & C alter the climatic circumstances and enhances the incidence of climate-related phenomena that include prolonged drought, flooding, high temperature, rainfall variability, and animal/plant pest/diseases outbreak (Kihila, 2017). The phenomenon has attracted much attention in recent decades all over the world, not only because of low rainfall but also because of the low ability of communities to cope with climate-related risks. As a result of this low capacity, farmers realize the extreme impact of CV & C such as drought, which is regularly supplemented by ecological decline, the decimation of livestock herds, widespread food insecurity, mass migration, and great loss of human life (Bergquist *et al.,* 2019). Bergquist *et al.* (2019) reported that agriculture is the most susceptible sector to CV & C because the phenomenon affects the most two important agriculture inputs; rainfall and temperature. The longstanding shift in rainfall patterns and fluctuating temperature are expected to have a negative impact on agriculture. Furthermore, CV & C affect agriculture through the unexpected eruption of crop and livestock pests and diseases, dropping water supply, irrigation and enhancing the severity of soil erosion. These climatic threats are becoming the main forces challenging the livelihood of most farmers. The rural community, for whom agriculture is the prime source of food, employment, and revenue, is the most affected due to its susceptibility to CV & C.

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Regardless of the worldwide coverage of CV & C, there is a great variation in the vulnerability depending on the location, coping ability, also other socioeconomic and environmental factors (Mequannt *et al.,* 2020). Kihila (2017) reported that in Africa, the impact of CV & C is believed to be higher which is contributed by low coping capacity and over-dependence on rain-fed agriculture. The negative impact of CV & C in Africa strongly impacts agricultural production that manifests through frequent floods, drought, eruption of crops and livestock pests and disease, high temperatures, and earthquakes (FAO, 2016). Over 70% of the rural population in sub-Saharan Africa (SSA) relies on rain-fed small-scale agriculture for subsistence and livelihood (FAO, 2016). This dependency makes the rural population susceptible to the negative impact of CV & C implying that the tragedy not only affects farming activities but also increases the level of poverty in the already vulnerable communities (Mequannt *et al.,* 2020).

The CV & C impact on agriculture is said to be stronger and the magnitudes of these impacts are expected to either remain the same or intensify (Kihila, 2017). According to URT (2016) in Tanzania as in most African countries, agriculture depends mostly on rainfall. This makes agriculture and rural living, especially in semiarid environments, vulnerable to CV & C. It determines not only having sufficient food to eat but also whether they will be able to offer requirements to earn a living. The performance of the agricultural sector displays solid relations with the rainfall pattern and the rainfall deficiencies lead to food shortages and famines (Alemayuhu and Bewket, 2017). Farmers in the Manyoni district are facing diverse types of climate change-related risks, such as reduced or variable rainfall, high temperatures, crop and livestock pests and diseases outbreak, flooding, scarcity of water, and soil erosion (Alemayehu and Bewket, 2017). The CV & C donates to reduced agricultural production, and the future sustainability of the sector (Alemayehu and Bewket, 2017).

The Intergovernmental Panel on Climate Change (IPCC) considers coping strategies as short-term response measures to a sudden-onset crisis (e.g. food shortage, drought, and flood) (IPCC, 2007)). Planned coping strategies for CV & C are urgent in the semi-arid region including Manyoni district where populations are rainfall dependent for food production (Shirima *et al.,* 2017). Reducing exposure and sensitivity along with increasing coping capability and strengthening the coping processes through building on prevailing coping practices are suggested (Shirima *et al.,* 2017). Small-scale farmers of the Manyoni District use a range of options to cope with the negative impact of CV & C. Previous studies (Alemayehu and Bewket, 2017; Kihila, 2017; Mulinyac, 2017 and Shirima *et al.,* 2017), emphasized and focused on the use of coping strategies against CV & C to improve agricultural productivity. However, factors that influence the choices of adopted coping strategies is inadequate to strategically inform farmers and the agricultural sector at large. Therefore, this study highlight mostly adopted coping strategies and factors influencing their choices in Manyoni District.

2.0 Methodology

2.1 Description of the Study Area

The study was conducted in the Manyoni district which is among the 6 districts in Singida Region. Data collection took place between May and December 2019. The district lies between 6˚7˚S and 34˚35˚E covering an area of 28 620 km^2 is about 58% of the entire area of the Singida Region. The rationale for choosing Manyoni is based on the ground that the district lies within the semiarid areas of Tanzania and has been experiencing food shortages as a result of prolonged drought (Benedict and Majule, 2015). Also, the district's dependence on rainfall for agriculture production exceeds 95% (NBS, 2019). In addition, the district forms part of the semi-arid central zone of Tanzania which experiences low rainfall that ranges from 500 mm to 700 mm per annum with high geographical, seasonal, and annual variations (Sawe *et al.,* 2018). Figure 2.1 shows sites involved in the study

The wards involved in the study were Sanza, Heka, and Manyoni from the Western part of the district, while Sasajila, Makutupora, and Maweni from the Eastern part. According to Singida's Socio-economic profile, the Eastern part is an area with a low population but with a high proportion of households owning livestock, mainly cattle (URT, 2017). The zone has low rainfall averaging between 500 mm to 650 mm per annum (URT, 2017). The soils vary from reddish-brown loamy sands to dark grey and black cracking clays in the valleys and depressions. The major crops grown are maize, sorghum, millet, paddy, groundnuts, cassava, and beans. Furthermore, the Western part experiences low rainfall of 500 mm to 700 mm per year. The soils are reddish loamy sands with dark grey to black clays in valleys and depressions. The major crops grown are maize, millet, sorghum, cassava, sweet potatoes, and groundnuts. Wards and villages were chosen because they receive low rainfall, hence facing prolonged drought throughout the year. Therefore, small-scale farmers have over the years adopted several climate coping strategies such as selling livestock, off-farm employment, supplementing livestock feeds, decreasing quantity, frequency, and diversity of meals, stock movement, wetland farming, petty business (charcoal and firewood selling) and remittances (Shirima *et al.,* 2017).

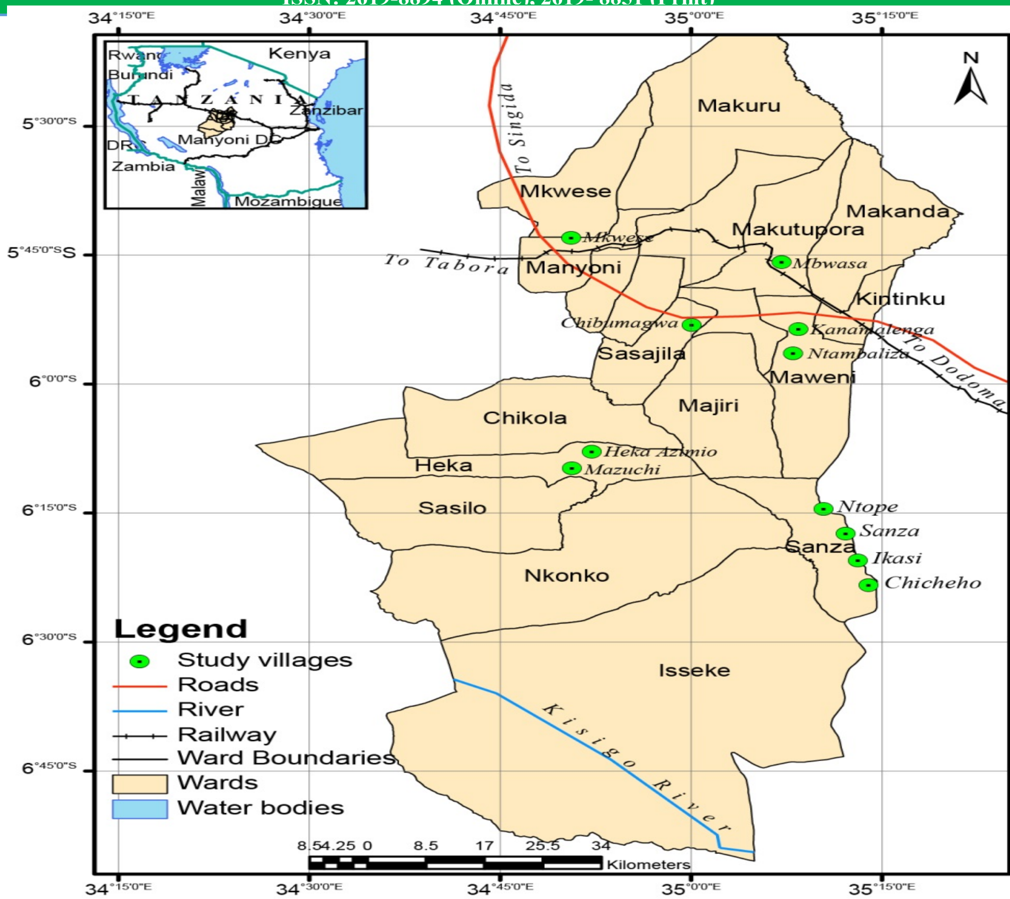

Figure 2.1: Map of the study area (Source: NBS, 2012)

2.2 Research Design, Method, and data collection tools

The study used a cross-sectional research design that allows data collection at a single point in time and has a greater degree of accuracy and precision in social science studies as compared to other research designs (Casley and Kumar, 1998; Creswell, 2003). As reported by Kesmodel (2018), cross-sectional studies allow the examination of multiple factors and multiple outcomes in one single study. The study population constituted small-scale farmers producing sorghum. The data collection method was a household survey with the use of a structured questionnaire with both closed and open-ended questions.

2.3 Sampling procedures and sample size

The sampling procedures involved purposive selection of the wards involved in the study. Subsequently, a simple random sampling was adopted to select villages and respondents. In 11 villages, a sub-sample of 30 households from each village was randomly selected making a total sample size of 330 for the survey. A minimum subsample of 30 in each village was considered because the study population was homogeneously composed of small-scale farmers producing sorghum. For the homogenous population, a minimum sub-sample of 30 selected randomly is a true representative of the population and it is adequate for statistical data analysis (Martinez-Abrain, 2014). Combining the homogeneousness of the population, and the fact that the study used a random sampling technique, which is a rigorous sampling method, the sub-sample of 30 irrespective of the village population size was important to evade avoidable wastage of resources that could occur in proportionate sampling techniques that reflect the size of each stratum (Mgoba and Kabote, 2020).

2.4 Data processing and analysis

Data analysis was done using both descriptive and inferential analysis. Descriptive statistics were used to obtain the frequency, percentage, mean, and standard deviation of coping strategies used by farmers, and the factors influencing the adoption of coping strategies. Under the inferential statistics, this study used a multivariate probit (MVP) econometric technique, which concurrently models the influence of the set of explanatory variables on each of the coping strategies, while permitting the unobserved factors (error terms) to be freely correlated (Belderbos *et al.,* 2004; Lin *et al.,* 2005). The multivariate probit analysis was estimated using STATA software version 16. The study follows Lin *et al.* (2005) in formulating the multivariate model. The dependent variables were four dummy variables; off-farm employment, decrease meals (quantity, frequency, and diversity), supplemented livestock feeds and selling of livestock. We employed a multivariate probit model because these four dependent variables are mutually inclusive, which means a small-scale farmer could use more than one CV & C coping strategies (Rahut and Ali, 2018). In addition, the MVP model is useful in determining factors influencing choices when you have more than two categories of the dependent variable that is measured at the nominal level, while independent variables are continuous and dummy in nature (Wuensch, 2014).

The choice of the model was guided by a utility maximization theory of decision making, which argues that individuals are rational, and if faced with the decision to choose several substitutes will prefer the choice that provides the maximum level of utility. In that regard, the choice of a given coping strategy can be considered a function of the expected utility derived from using that strategy (Fishburn, 1969).

MVP results tested hypothesis:

i. ***H₀:*** Independent variables (Age, Household size, Farm size, Farming experience, Technology uses, Annual Income, Extension services, Livestock ownership, Shift in rain season) have no impact on the dependent variables (Livestock selling, Off-farm employment, decrease meals, supplement livestock feeds)

ii. ***Hₐ:*** Independent variables (Age, Household size, Farm size, Farming experience, Technology uses, Annual Income, Extension services, Livestock ownership, Shift in rain season) have an impact on the dependent variables (Livestock selling, Off-farm employment, decrease meals, supplement livestock feeds)

Hence, farmers choose a coping strategy if the expected utility from it exceeds that of other coping strategies such that:

$$Y^* = Y_i \text{ If } V_i > V_j \text{ ……………………………………(1)}$$
$$= Y_j \quad \text{if } V_j \leq V_i$$

Where, Y_i represents the strategy type i, Y_j an alternative strategy type j, V_i and V_j the corresponding expected indirect utility values of strategy type i and its alternative j, while Y* represents the strategy type chosen. Therefore, we can view the farmers' decisions on the coping strategy implementation within a random utility discrete choice model. This is particularly appropriate for modelling discrete choice decisions such as between coping strategies because it is an indirect utility function where an individual with specific characteristics associates an average utility level with each alternative coping strategy in a choice set. In this framework, the utility function is assumed to be known for each farmer but some of its components are unobserved by the researcher. This unobserved part of the utility is treated as a random variable. For the i strategy decision the expected indirect utility was then modelled as the sum of the observed variables and non-observed random component:

$$V_i = \beta^1 i X_i + \varepsilon_i \text{ ……………………………………(2)}$$

As in Equation (1), we can write the choice utility of implementing any alternatives as follows:

$$V_i = \beta^1 j X_j + \varepsilon_j \text{ ……………………………………(3)}$$

Where;

$\beta^1 i$ and $\beta^1 j$ are vectors of parameters. Hence, farmers can decide simultaneously whether to choose one or more coping strategies conditional upon the vectors of explanatory variables X_I and X_J. In this approach, we can use a multivariate probit model (MVP) to study the farmers' joint decisions to coping strategies. Following Equation (2) and (3) the empirical specification of MVP takes the form:

$$Y^*ij = V_i = \beta^1 i X_i + \varepsilon_1 \text{ ………………………..……(4)}$$

With j= 1, 2, 3, 4, 5

$$Y_i = 1 \text{ if } Yi^* > 0 \text{ and 0 otherwise……………………(5)}$$

Where,

Yi* is an unobservable latent variable denoting the probability of choosing j type of coping strategy, for i = 1 (selling livestock), i = 2 (off-farm employment), i = 3 (reducing quantity, frequency and diversity of meals) i = 4 (supplement livestock feeds). Thus, empirically the model can be specified as follows:

$$Y_i 1 = \beta_1 X_{ij1} + \varepsilon_{i1} \text{ ……………………………………(6)}$$
$$Y_i 2 = \beta_2 X_{ij2} + \varepsilon_{i2} \text{ ………………………………… ..(7)}$$
$$Y_i 3 = \beta_3 X_{ij3} + \varepsilon_{i3} \text{ ……………………………….....(8)}$$
$$Y_i 4 = \beta_4 X_{ij4} + \varepsilon_{i4} \text{ ……………………………………(9)}$$

Where, $Y_I 1$= 1, if a farmer chooses the selling of livestock (0 otherwise), $Y_I 2$ = 1, if the farmer chooses off-farm employment (0 otherwise), $Y_I 3$=1 if the farmer chooses to decrease the quantity, frequency, and diversity of meals (0 otherwise), $Y_I 4$=1, if a farmer chooses to supplement livestock feeds (0 otherwise), Xi = vector of factors influencing the choice of coping strategy (Annual income, Age, farm size, farming experience, household size, the technology uses, ownership of livestock, a shift in rain season, extension services), βj = vector of unknown parameters (j=1,2,3,4,), and ε = is the error term. To estimate the four equations (6) – (9) it assumes that the error term (ε1, ε2, ε3, and ε4) may be correlated. Then, instead of being independently estimated, they are considered to be a multivariate limited dependent-variable model in which the four error terms follow a multivariate normal distribution with zero mean and variance and covariance matrix.

In the multivariate model, where the choice of several coping strategies is possible, the error terms jointly follow a multivariate normal distribution (MVN) with zero conditional mean and variance normalized to unity (for identification of the parameters) where (µx1, µx2, µx3, µx4) MVN~ (0, Ω) and the symmetric covariance matrix Ω is given by:

$$\Omega=\begin{bmatrix} 1 & \rho \times 1 \times 2 & \rho \times 1 \times 3 & \rho \times 1 \times 4 \\ \rho \times 2 \times 3 & 1 & \rho \times 2 \times 3 & \rho \times 2 \times 4 \\ \rho \times 3 \times 1 & \rho \times 3 \times 2 & 1 & \rho \times 3 \times 4 \\ \rho \times 4 \times 1 & \rho \times 4 \times 2 & \rho \times 4 \times 3 & 1 \end{bmatrix} \quad \text{..........(10)}$$

Of particular interest are the off-diagonal elements in the covariance matrix, which represent the unobserved correlation between the stochastic components of the different types of strategies. This assumption means that equation (10) generates the MVP model that jointly represents the decision to choose a particular coping strategy. This specification with non-zero off-diagonal elements allows for correlation across error terms of several latent equations, which represent unobserved characteristics that influence the choice of alternative strategies. Following the formula used by Cappellari and Jenkins (2003), the log-likelihood function associated with a sample outcome is then given by:

$$\ln = \sum_n^N \omega_i \ln \emptyset(\mu_1, \Omega \quad \text{................................(11)}$$

Where ω is an optional weight for observation I and Φi is the multivariate standard normal distribution with arguments μ_i and Ω, where μ_i can be denoted as:

$$\mu_i = (k_{i1}\beta_1 x_{i1}, k_{i2}\beta_2 x_{i2}, k_{i3}\beta_3 x_{i3}) \quad \text{.................(12)}$$

$$\Omega_{jk} = \Omega_{jk} = k_{ij} k_{ik} \rho_{jk} \text{ for } j \neq k \text{ k=1,2,3...With } K_{ik} = 2y_{ik} - 1 \quad \text{.....(13)}$$

Table 2.1: List and definition of variables

Variable	Description of Variables
Dependent	
Selling of livestock	Dummy: 1 if a farmer adopted selling of livestock and 0 if not
Off-farm Employment	Dummy: 1 if a farmer adopted off-farm employment and 0 if not
Decrease the number of meals	Dummy: 1 if a farmer adopted a decreased number of meals and 0 if not
Supplement Livestock Feeds	Dummy: 1 if a farmer adopted supplement livestock feeds and 0 if not
Independent	
Age	Total number of years of a farmer from birth to the date of interview
Household size	Total number of family members
Farm size	Total land owned by household in hectares
Farming Experience	Total number of farming in years
Technology uses	Dummy: 1 if a farmer makes use of technology and 0 if not
Annual income	The total annual income earned by a farmer in Tanzania shillings
Extension Services	Dummy: 1 if a farmer accesses extension services and 0 if not
Livestock ownership	Dummy: 1 if a farmer owns livestock and 0 if not
The shift in rain season	Dummy: 1 if there is a shift in rain season and 0 if not

3.0 Results and Discussion

3.1 Social-economic and demographic characteristics of respondents

Tables 3.1 shows results for descriptive statistics of the social-economic and demographic characteristics of respondents in the study areas. Findings show that 89.7% of the respondents acquired different levels of formal education. The results further show that the respondents in the study area had a mean age of 46 years with nearly 59% of them falling under the age of between 35 and 60 years. In addition, 54.8% of households had 5 – 8 members, 55.2% of the respondents owned 0.51 – 1 ha of land, more than 77% of heads of households were men, and the majority of them were married (79.1%) (Table 3.1).

It is plausible from the level of education that small-scale farmers in the study area are likely to be trainable and have the potential to read written materials including materials for CV & C. This is in line with the findings of Damnyag *et al.* (2021), who reported that educated farmers are in a better position to comprehend CV & C and its associated risks. Concerning the age of the respondents, it is reasonable to say that majority of the people in the study area were active and capable of providing labour required for agricultural production. According to NBS (2017), the age group that ranges from 15 to 60 is considered to be active and energetic. This finding implies that the age group of 35 – 60; apart from being an active working group had enough experience to notice weather changes and take appropriate coping strategies for survival. These results confirm the study findings in the central land of Ethiopia by Arragaw and Woldeam (2017). The two authors reported that the household heads' age rises the possibility to take up coping measures because adult and older farmers have long years of farming experience to notice changes in their environment and to take up coping strategies to survive with CV & C.

Table 3.1: Social-economic and demographic characteristics of respondents (n= 330)

Parameters		Sanza (n=120)	Heka (n=60)	Sasajila (n=30)	Makutupora (n=30)	Maweni (n=60)	Manyoni (n=30)	Total (n=330)
Education	No formal	14 (11.7)	4 (6.7)	4 (13.3)	3 (10)	7 (11.7)	2 (6.7)	34 (10.3)
Level	Formal	106 (88.3)	56 (93.3)	26 (86.7)	27 (90)	53 (88.3)	28 (93.3)	296 (89.7)
Age of	15 - 24	6 (5)	0 (0)	1 (3.3)	3 (10)	0 (0)	0 (0)	10 (3)
Household	25 - 34	37 (30.8)	8 (13.3)	3 (10)	3 (10)	17 (28.3)	6 (20)	74 (22.4)
head	35 - 60	57 (47.5)	40 (66.7)	17 (56.7)	20 (66.7)	41 (68.3)	19 (63.3)	194 (58.8)
	≥ 61	20 (16.7)	12 (20.0)	9 (30)	4 (13.3)	2 (3.3)	5 (16.7)	52 (15.8)
Household	1 - 4	34 (28.3)	9 (15)	11 (36.7)	12 (40)	21 (35)	5 (16.7)	92 (27.9)
Size	5 - 8	66 (55)	37 (61.7)	13 (43.3)	14 (46.7)	30 (50)	21 (70)	181 (54.8)
	≥ 9	20 (16.7)	14 (23.3)	6 (20)	4 (13.3)	9 (15)	4 (13.3)	57 (17.3)
Farm Size	0.20-0.50	9 (7.5)	4 (6.7)	2 (6.7)	4 (13.3)	7 (11.7)	3 (10)	29 (8.8)
(hectare)	0.51 - 1	58 (48.3)	29 (48.3)	19 (63.3)	20 (66.7)	40 (66.7)	16 (53.3)	182 (55.2)
	1.01 - 3	31 (25.8)	14 (23.3)	5 (16.7)	3 (10)	8 (13.3)	7 (23.3)	68 (20.6)
	≥ 3.01	22 (18.3)	13 (21.7)	4 (13.3)	3 (10)	5 (8.3)	4 (13.3)	51 (15.5)
Sex	Female	31 (25.8)	5 (8.3)	7 (23.3)	9 (30)	13 (21.7)	8 (26.7)	73 (22.1)
	Male	89 (74.2)	55 (91.7)	23 (76.7)	21 (70)	47 (78.3)	22 (73.3)	257 (77.9)
Marital	Single	5 (4.2)	0 (0)	0 (0)	0 (0)	0 (0)	1 (3.3)	6 (1.8)
Status	Married	93 (77.5)	55 (91.7)	23 (76.7)	20 (66.7)	48 (80)	22 (73.3)	261 (79.1)
	Divorced	14 (11.7)	2 (3.3)	3 (10)	5 (16.7)	10 (16.7)	4 (13.3)	38 (11.5)
	Widow	8 (6.7)	3 (5)	4 (13.3)	5 (16.7)	2 (3.3)	3 (10)	25 (7.6)

NB: The number in brackets indicates the per cent

As for the household size, it can be deduced that the population in the study area provides an adequate workforce for food and agricultural production. According to NBS (2019) household with 5 – 8 members is considered to be a medium household size. A household with more than 5 people can make use of the labour force available to complete several agricultural tasks including the adoption of coping strategies against CV & C. The other assumption is households with 5 – 8 members can divert part of the labour force to off-farm activities to earn income to finance agriculture production including coping strategies to counteract the negative impact of CV & C. This observation conforms to what has been reported in the literature by Ojo and Baiyegunhi (2018) in Southwestern Nigeria, that household with enough manpower can supply extra labour to non-farm activities and the income created could be invested in CV & C coping strategies. Additionally, farm size was assessed and findings in Table 3.1 show that 55.2% of respondents had 0.51 – 1 ha. According to Agriculture Sector Development Strategy II (URT, 2015), a land size that ranges between 0.5 – 1 ha is considered to be a small farm size. This is common in the village context and is one of the characteristics of small-scale farmers that in most cases own small size of land that produces for subsistence purposes (FAO, 2015). FAO (2015) emphasizes that ownership of small size of farms is attributed to poor tillage tools (hand hoe) and insufficient capital to manage large farm sizes. The observation of this study is similar to the study in Mbarali and Kilolo districts by Pauline (2015) that most farmers cultivate small plots, which is attributed to poor tillage tools, an inadequate workforce, and capital to manage large plots. In addition, the results of this study are similar to a study reported in the Kilombero district, by Balama *et al.* (2013) on climate coping strategies by local farmers, the majority of the household had a land size that are within 0.28 – 1 ha which was claimed to be relatively small.

Since the majority of heads of households were male, it can also be argued that decision-making regarding the utilization of resources and adoption of CV & C coping strategies rests on men. Male farmers are in a better position to access technologies and climate change information as compared to females, and this contributes to male-headed households practising diverse coping strategies against CV & C compared to female-headed households. These results have also been reported by Mequannt *et al.* (2020) in Ethiopia who reported that the choice of coping strategy was a gender-sensitive judgment. Male household heads are somewhat risk-averse and have more access to technologies, climate change information, land, and other resources relative to female household heads. Additionally, it is reported by Beuchelt (2016) that women in Africa are denied ownership of critical resources (Land and cash), which in most cases weakens their capacity to carry out resource-intensive agriculture innovation including coping strategies against the adverse impact of CV and C. Furthermore, findings show that 79.1% of respondents were married. It is this study's authors' perception that married households are more capable to respond to CV & C through coping strategies due to available options of resources including manpower, land, financial capacity, and information accessibility. Female-headed households are more susceptible to the impact of CV & C due to a lack of materials possession such as financial capital, manpower, land, and information accessibility. Also, female-headed households are more susceptible to poverty, a situation that reduces the response options of the household when climatic adverse impacts occur. The current study is in line with the study in Northern Uganda by Atube *et al.* (2021), which reported that households with married heads are more likely to accept coping strategies since they seem to have different agricultural interactions including extension agents and agro-input dealers compared to their unmarried counterparts.

3.2 Farmers' coping strategies against climate variability and change

To live with the adverse impact of CV & C, farmers in the study areas used a variety of coping strategies that included supplementing livestock feeds, stock movement, off-farm employment, remittances, reduced number of meals per day, selling of livestock, charcoal and firewood business and wetland farming (Figure 3.1). Most of these strategies have been in use in different parts of the Manyoni district in response to CV & C. Findings from Figure 3.1 show that four of the eight strategies were implemented by more than half of the small-scale farmers. These involved the selling of livestock (67.6%), off-farm employment (55.8%), supplementary livestock feeds (52.1%), and a decreased number, frequency, and diversity of meals (50.6%). These results imply that to strengthen the capacity to survive with the impact of CV & C, small-scale farmers need to diversify their economic activities apart from crop production which is heavily dependent on rainfall. These activities may include the domestication of livestock and off-farm activities such as casual labour in other farm plots. Livestock in most cases treated as a living bank and animals are sold when in need of cash to handle some family problems including coping with CV & C. These findings are in line with the studies conducted in Ghana and South Africa by Benjamin and Richard (2019) and Bahta (2020) respectively, reported that to minimize the impact of agricultural drought, it is important to diversifying livelihood strategies through income-generating activities within and outside agriculture is required.

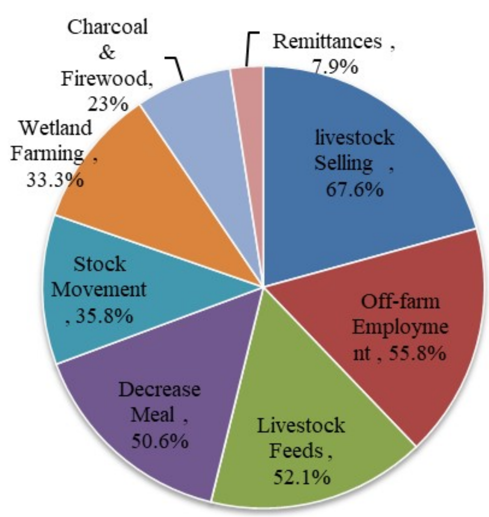

Figure 3.1: Coping strategies

Furthermore, during prolonged drought, households used their food reserve wisely by decreasing the number of meals per day from three meals (breakfast, lunch, and dinner) to two or one meal. In addition, food diversity through additions to the main dish such as fruits or tea/coffee, or milk were absconded and sometimes used as the main dish. Additionally, during the rainy season when grasses were available in abundance, pastoral farmers collect and dried them and kept as hay or processed as silage, retaining crop residue from harvest for livestock fodder in times of drought. Similar coping strategies were informed by Adino *et al.* (2018) and Salmoral *et al.* (2020), in Ethiopia and the United Kingdom respectively reported that small-scale farmers reduced portions and frequency of meals to survive with CV & C. Also, the same authors reported that most drought responses by farmers were reactive short-term coping strategies to address livestock feed shortages, with three main strategies; forage process and conservation, hay process, and selling of livestock to decrease feed demand and to acquire income.

3.3 Factors Influencing Choices of Coping Strategies Adopted by Farmers

This section discusses the results from the multivariate probit model (MPV). The likelihood ratio test (chi^2 (36) = 244.072, P > 0.000) of the independence of the error terms of the different coping equations was rejected (Table 3.2). Therefore, this study adopted the alternative hypothesis of mutual independence among the multiple coping strategies. Therefore, the results support the use of the multivariate model. The model was highly significant (P = 0.000). On the test of multicollinearity, the results indicated an average of 1.17 as the variance inflation factor (VIF) for independent variables. According to Zach (2020), when the VIF value lies between 1 and 10 then there is no multicollinearity.

3.3.1 Off-farm employment

Findings from the study (Table 3.2) show that household size, farming experience, household annual income, and availability of extension services were the major factors influencing the choice of off-farm employment as one of the coping strategies adopted by farmers in the study areas.

(i) Size of Household

The results show that the size of the household influenced engagement of off-farm employment as a coping strategy at P = 0.000. As household size increases, the probability of engaging in off-farm employment increases by 0.155 times. This suggests that households with a large number of members provide an opportunity to split the workforce (manpower) into off-farm employment to generate income that could be invested in CV & C coping strategies. Large households can make use of mind diversity and share different opinions on how to survive the adverse impact of CV & C. This finding is supported by the study of Mequannt *et al.* (2020) in Ethiopia who reported that households with a large family increased coping decision mechanisms including diverting part of the labour force to non-farm activities to make more income to reduce the impact of CV & C. Ojo and Baiyegunhi (2018) in

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Southwestern Nigeria found a positive association between the size of household and adoption of off-farm employment and reported that large household size could help complement, perceive, discuss and share climate-related interpretations which could affect positively the perception of a farmer on CV & C.

(ii) Farming experience

Farming experience showed a positive and significant contribution to the adoption of coping strategies including off-farm employment at a p-value of 0.015. As the farming experience of household head increases, the probability to engage in off-farm employment increases by 0.039 times. This implies that a farmer with more experience would be in a position to predict when CV & C occurring in the area and which coping strategy works well in that particular area. Similar findings were obtained by Ojo and Baiyegunhi (2018) in Southwestern Nigeria who reported that farming experience increases the probability of adopting off-farm employment as a coping strategy to live with CV & C.

(iii) Household annual income

The results reveal that the total yearly household revenue had a positive and significant influence on off-farm employment ($\beta = 0.212$ and $P = 0.008$). This study assumes that the increase in household annual income increases households' ability to adopt off-farm employment as a coping strategy to survive with CV & C as in most cases Off-farm employment requires financial capacity for investment. This finding aligns with another study by Atube *et al.* (2021) and Bahta (2020) in Uganda and South Africa respectively who reported that per capita income has a positive effect on farmers' decision to take up coping strategies including off-farm employment.

(iv) Extension services

The coefficient of access to extension services was positive and statistically significant influencing the choice of off-farm employment ($\beta = 0.424$, $P = 0.007$). This implies that extension services facilitate the availability and dissemination of agricultural information including economic activities diversification through off-farm employment. Comparable results were informed by Ojo and Baiyegunhi (2018) and Ali *et al.* (2020) in South Africa and Sudan respectively who reported a positive impact of extension services and adoption of coping strategies as extension services increased the disposal of information on climate risk and coping alternatives.

3.3.2 Decrease quantity, frequency, and diversity of meals

(i) Farm size

Findings from table 3.2 showed Farm size with a negative significant impact on the adoption of reducing food consumption (-0.062, $p = 0.000$). This implies that as the farm size raises the possibility of adopting a decreased quantity, frequency, and diversity of meals decreases. The bigger the farm size the higher the demand for well-fed and energetic manpower to devote their energy to farm operations. This result counteracts the findings by Mequannt *et al.* (2020) and Pauline (2015) in Ethiopia and Mbarali and Kilolo districts respectively who reported that farmers with bigger farming land sizes are more likely to produce more and expected to adopt any coping decision because they have enough resources.

(ii) Farming experience

The study findings revealed that the farming experience of a small-scale farmer (Table 3.2) had a positive and significant impact on the adoption of food consumption reduction ($\beta = 0.044$, $p = 0.000$) as a coping strategy to the impact of CV & C. The reason is that experienced farmers have a wealth of diverse knowledge and techniques to survive with the impact of CV & C. This positive relationship was also observed in Uganda and Ethiopia by Atube *et al.* (2021) and Belay *et al.* (2017) who reported that experience farmers have a wealth of indigenous knowledge and capacity to withstand the impact of CV & C through decrease quantity and frequency of meals consumed by members of household per day.

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Table 3.2: Factors influencing the choices of coping strategies adopted by farmers

	Coef.	Std.Err.	Z	P>z	[95%Conf.	Interval]
Off-farm Employment						
Age of Household head	0.002	0.006	0.390	0.699	-0.010	0.015
Size of Household	0.155	0.031	2.870	0.000	0.217	0.092
Farm Size	0.015	0.016	0.950	0.340	-0.016	0.047
Farming Experience	0.015	0.007	2.060	0.039	0.031	0.000
Technology Uses	0.003	0.156	0.020	0.983	-0.304	0.310
HH Annual Income	0.212	0.079	2.670	0.008	0.056	0.368
Extension Services	0.424	0.156	2.710	0.007	0.117	0.730
Livestock Ownership	0.029	0.161	0.180	0.855	-0.286	0.345
Shift in Rain Season	-0.307	0.157	-1.960	0.051	-0.615	0.000
Decreases Number of Meals						
Age of Household head	-0.007	0.006	-1.100	0.273	-0.020	0.005
Household Size	0.005	0.039	0.140	0.886	-0.072	0.084
Farm Size	-0.062	0.017	-3.360	0.000	-0.096	-0.027
Farming Experience	0.044	0.009	4.770	0.000	0.026	0.063
Technology Uses	-0.885	0.158	-5.580	0.000	-1.196	-0.574
HH Annual Income	0.153	0.081	1.890	0.058	-0.005	0.312
Extension Services	-0.048	0.159	-0.300	0.763	-0.361	0.265
Livestock Ownership	-0.323	0.180	-1.790	0.073	-0.676	0.029
Shift in Rain Season	-0.477	0.173	-2.760	0.006	-0.817	-0.137
Supplement Livestock Feeds						
Age of Household head	-0.002	0.006	-0.330	0.742	-0.014	0.010
Household Size	-0.021	0.031	-0.670	0.502	-0.083	0.040
Farm Size	0.005	0.014	0.360	0.715	-0.023	0.034
Farming Experience	0.003	0.007	0.480	0.633	-0.011	0.018
Technology Uses	-0.305	0.155	-1.970	0.049	-0.609	-0.001
HH Annual Income	0.152	0.072	2.120	0.034	0.011	0.294
Extension Services	0.254	0.150	1.690	0.092	-0.041	0.550
Livestock Ownership	0.786	0.165	4.740	0.000	0.461	1.111
Shift in Rain Season	0.285	0.157	1.820	0.069	-0.022	0.594
Livestock Selling						
Age of Household head	-0.002	0.006	-0.330	0.743	-0.014	0.010
Household Size	-0.017	0.034	-0.510	0.613	-0.083	0.049
Farm Size	-0.007	0.014	-0.500	0.615	-0.036	0.021
Farming Experience	0.007	0.007	1.010	0.315	-0.007	0.021
Technology Uses	0.493	0.154	3.318	0.001	0.189	0.796
HH Annual Income	-0.221	0.083	-2.670	0.008	-0.059	-0.384
Extension Services	-0.173	0.157	-1.100	0.271	-0.482	0.135
Livestock Ownership	0.838	0.164	5.090	0.000	0.515	1.161
Shift in Rain Season	0.087	0.165	0.530	0.595	-0.236	0.412

(iv) Technology use

Technology use showed a negative and significant impact in influencing the choice of meals decrease in terms of quantity, frequency, and diversity. Findings from Table 3.2 show that farmers using technology in farming (β = -0.885 and P = 0.000) were less likely to adopt a decrease in quantity, frequency, and diversity of meals as a coping strategy. This result implies that the use of technology results in more production and achieving food security, hence no need to adopt a decrease in meals' quantity, frequency, and diversity. This result is in agreement with the study conducted in Ethiopia and Tanzania by Solomon *et al.* (2012), who reported that the use of technology in agriculture results in the achievement of food security, ability to withstand risks related to climate change, and increase production.

(v) The shift in rain season

The shift in rain season is less likely (β = -0.477 and P = 0.006) contributing to the adoption of meal reduction in terms of quantity, frequency, and diversity as a coping strategy. This finding implies that a shift in rain season as a result of CV & C is a common phenomenon and small-scale farmers preferred to opt for other coping strategies options rather than reduction of meal consumption. Similar results were also realized in Ethiopia and Sub-Saharan Africa by Amelework *et al.* (2016) and Rodenburg *et al.* (2020) who reported that to copy with uncertain rainfall, the majority of farmers opted for other coping strategies such as off-farm employment, wetland farming, and selling of livestock

3.3.3 Supplement livestock feeds

(i) Technology uses

Findings from Table 3.2 show that farmers using technology in supplementing livestock feeds (β = 0.305 and P = .049) were more likely to engage themselves in supplementing livestock feeds as their coping strategy. The preparation and conservation of livestock feed such as silage and hay require technological aspects for long-lasting. Farmers using technology in supplementing livestock feeds achieve more production, food security, and the ability to withstand risks related to CV & C. More production as the result of technology use provides an opportunity for livestock survival during prolonged drought. Similar results were also realized in Lushoto Tanzania and Ethiopia by Shikuku *et al.* (2017) and Belay *et al.* (2017) in Ethiopia who reported that technology uses is the proxy determinant in supplementing livestock feeds to survive with the impact of CV & C.

(ii) Household annual income

As the income of Small-scale farmers increases (Table 3.2), the probability of adopting supplement livestock feeds as their coping strategy increases as well (β = 0.152 and P = 0.034). This is because supplementing livestock feeds requires technology uses that demand financial capability. Income increases address financial challenges among small-scale farmers and enable them to adopt supplement livestock feeds as their coping strategy. This positive relationship was also observed by Marie *et al.* (2020) in Northwestern Ethiopia who reported that wealthier farmers are more probable to employ coping strategies including supplementing livestock feeds to lessen the impact of climate change

(iii) Livestock ownership

Findings from table 3.2 revealed that owning livestock was positive and significantly (β = 0.786 and P = 0.000) contributed to supplementing livestock feeds. This means that farmers keeping livestock need to cope with CC & V through the adoption of supplementing livestock feeds as a coping strategy. Livestock owners must learn to prepare and store livestock feeds to use at times of drought, and this helped them to maintain their flocks healthy. A similar strategy was adopted by pastoralists in Monduli District, in terms of collecting fodder during the rainy season, and after harvest, they retain crops residuals of maize and "legumes" to feed their animals during prolonged drought (Kimaro *et al.,* 2018).

3.3.4 Selling of livestock

(i) Technology uses

The use of technology showed a positive and significant (β = 0.493 and P = 0.001) (Table 3.2) impact on selling livestock as a coping strategy. This implies that small-scale farmers using technology opted to sell their livestock and use the income generated to invest in crop production through the use of improved seeds and other farm inputs. This study is inconsistent with the findings of Bahta (2020) and Shikuku *et al.* (2017) in Lushoto and South Africa respectively, who reported that respondents using technology had prior knowledge of the intensity and frequency of agricultural drought and they do not want a risk of losing their livestock due to climate change impact.

(ii) Household annual income

The findings from Table 3.2 show that increasing the household income decrease the probability of selling livestock as a coping strategy (β = -0.221, p = -0.008). This finding implies that when the income of small-scale farmers increases; mostly do not prefer selling their livestock and choose a different coping strategy to survive with CV & C impact. Farmers with more income from other sources depend less on livestock and wish to maintain their flock size as pastoralists mostly prefer to see their flock increase and not decrease. It is common among small-scale farmers in Tanzania to sell their livestock only when facing financial difficulties. Comparable results were reported by Bahta (2020) in South Africa who reported that small-scale farmers used livestock as a form of saving and sold them only when financial needs arise.

(iii) Livestock ownership

Livestock ownership positively and significantly increased the possibility of selling livestock as a coping strategy to survive CV & C (β = 0.838, p = 0.000) (Table 3.2). The majority of small-scale farmers keep livestock that can be sold when in need of cash and at times of stress as a result of CV & C. Livestock is an essential form of security and serves as an asset and insurance against shocks however in some scenarios farmers sold livestock to reduce stock and avoid the risk of them dying during hazards, especially drought. Similar findings were reported in Ngorongoro and Monduli by Mwakaje (2013) and Kimaro *et al.* (2018) respectively.

4.0 Conclusions and Recommendations

The study focused on determinants of farmers' choice of coping strategies to CV & C amongst small-scale farmers in the Manyoni district. The study rejected the null hypothesis that the independent variable (Factors that determine the choice of coping strategies) has no impact on the dependent variables (coping strategies). Thus, the alternative hypothesis of independent variables has an impact on coping strategies was accepted and adopted for the study. The study found out the four most widely practiced coping strategies for the impact of CV & C were selling of livestock, off-farm employment, decrease number, diversity, and frequency of meals per day, and supplementing livestock feeds. The results from the multivariate model show that the small-scale farmers' choice of coping strategies is statistically affected by factors such as the household head's age, size of household, farm size, farming experience, the use of technology, annual income, extension services, ownership of livestock and shift in rain season. The study concluded that, for small-scale farmers to survive with CV & C, adoption of coping strategies is important and inevitable. The study further identified the economic activities diversification through livestock keeping and off-farm employment as the key factors that helped small-scale farmers to mitigate the impact of CV & C and avoid over-reliance on crop production that is heavily hit by CV & C. Extension services are the significant determinant factor for the adoption of coping strategies and survival of small-scale farmers through agriculture information and innovation dissemination, awareness creation on CV & C and the importance of technology uses.

In light of the above, the study recommends that the government through the ministry of agriculture should invest in climate-resilient programs and formulate policies that will focus on addressing challenges facing small-scale farmers in the course of adopting coping strategies. Government policies and investment must be geared towards the support of education on coping strategies against CV & C, diversification in economic activities through off-farm employment, livestock keeping, and the use of technology in agriculture. Furthermore, the government should formulate and/or review policies on extension services to ensure deployment of extension agents in every villages and empower them to establish demonstration plots to practically demonstrate and disseminate agricultural innovation.

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