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Factors Affecting the Choice of Adaptation Strategies to Climate Extremes: The Case of Smallholder farmers in Southern Zambia

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ABSTRACT

This study assesses the adaptation of smallholder farmers to climate extremes and its contributing factors in Zambia's southern province. The study employed primary data collected from 270 smallholder farmers, and these constituted the sample size. According to the study's findings, change crop variety was adopted by 43% of the farmers. Other strategies of adaptation that were employed include; agricultural insurance, change sow/harvest date, crop diversification and soil conservation. The findings also showed that the various strategies of adaptation (agricultural insurance, change sow/harvest date, crop diversification and soil conservation), correlated positively with age, education, distance, farming experience, ownership of a radio, an ox, a plough, and extension source. The study makes the following recommendations; (a) enhancing the education and awareness level of farmers towards climate extreme, (b) improving farmers' access to agricultural assets (plough, oxen etc), and (c) when developing and implementing adaptation strategies, farming experience should be taken into account.

Key words: Adaptation, Climate extreme, Smallholder farmers, Zambia

1. INTRODUCTION

The earth's climate is rapidly changing, according to scientific evidence, because of the rise in greenhouse gas emissions (Stern, 2006). The average temperature has risen because of increased greenhouse gas concentrations, with semi-arid and desert regions experiencing the effects more markedly (Anderson et al., 2010). Not only the long term change of climate (temperature and precipitation), the frequency and intensity of climate extremes (drought and flood) also have increased

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(IPCC, 2014). Weather events that are extreme have become more common in the world since the 1950s, with annual economic losses totaling USD 67 billion on average (Guha-Sapir et al., 2004). The total area affected by drought worldwide is expected to increase by 15-44% by the turn of this century (IPCC, 2012).

In many African countries, food security and human lives have been threatened due to unfavorable incidents of severe droughts and floods. For instance, from 1960 to 1990, droughts and floods extremes across south-eastern, southern and east Africa, and drought extremes south of the Sahara. Droughts have hit Southern Africa, Horn of Africa, and the Sahel since the late 1960s, causing an overall rise in dryness in Africa (Christensen et al., 2007). Further, consequences of this multiyear drought cycles include production loss and food scarcity (FAO, 2015), and severe famine (Few et al., 2004).

Most parts of Africa remain considerably vulnerable to drought's direct and indirect effects (Few et al., 2004). From 1980 to 2014, drought extremes in Sub-Saharan Africa impacted approximately 363 million people, with 203 million in eastern Africa, 86 million in southern Africa, 74 million in western Africa, and less than 1 million in central Africa. Over the four decades, the number of people impacted by drought rose dramatically, that is, 82 million in the 1980s, 90 million in the 1990s and 132 million people in the 2000s (FAO, 2015).

Washington and Preston (2006), extreme rainfall cycles and frequent flooding are part "of El Niño phase of El Nino Southern Oscillation (ENSO) events (e.g., 1982-1983, 1997-1998, 2006-2007)." The occurrence of these events result in considerable losses (economic and human). Floods in Mozambique in 2000, primarily, the Limpopo and Zambezi river valleys, left around half a million people homeless, 700 people died, and agricultural crops were destroyed, destroying livelihoods (Osman-Elasha et al., 2006). In the year 2003, extreme floods were experienced in North Africa, leading to the flooding of ephemeral rivers, East Africa along areas on Lake Victoria, northern part of Madagascar, and the northern part of Mozambique. Besides, in 2010, West Africa experienced floods and it was the worst flood by the River Niger recorded since 1929 (FEWS NET, 2003 and French, 2003/04).

Climate extremes have become more frequent and intense in Zambia in recent years. From 1990 to 2022, Zambia experienced seven droughts in 1991-1992, 1994-1995, 1997-1998, 2000-2001, 2001-2002, 2004-2005 (Jain 2007), and 2018-2019. In addition, floods were also reported in the

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farming seasons of 2007/08 and 2021/2022. This caused rain-fed crops in the fields to be destroyed, resulting in crop loss, destruction of farmlands, food insecurity and deepening poverty. As a result, a part of the population that relies on subsistence agriculture was kept below the poverty line of the country. It is widely acknowledged that climate extreme presents a critical and serious threat to Zambia's sustainable and socio-economic development (Jain 2007; Lekprichakul 2008 and Makano 2011). Therefore, actions to minimize the potential future impacts of such hazards remain critical (Ministry of Environmental Protection, 2016).

Zambia's southern province is the bread basket of the country and contributes (estimated at 18.25%) in terms of agriculture to the national output. Climate extreme impacts, are especially evident in this province. Agriculture production is negatively affected by extreme weather events such as droughts (Ngoma, 2008). Among the farmers in the province, there is a strong focus on monocropping, that is, maize production. Impediments such as price volatility, dry spells and animal diseases, have made agriculture in the province extremely difficult, resulting in low agricultural productivity (Neubert et al., 2011).

Despite the fact that adaptation to climate extremes has been identified as an effective risk mitigation strategy for farmers, (Huang et al., 2014), there has been little empirical research into how extreme weather events influence farmers' adaptation decisions. By definition, adaptation is the process by which a farmer adjusts to current or anticipated climate extreme effects. According to our review of relevant literature, we note that adaptation has many times been looked at in relation to climate change, unlike to climate extremes. The former is long-term and includes temperature and precipitation, whereas the latter is short-term and includes droughts and floods.

In Zambia, most of the scholarly work focuses on climate change impacts on agriculture (Jain, 2007 and Kalantary, 2010), climate change perceptions by farmers (Nyanga et al., 2011), opportunities for climate change adaptation (Bwalya, 2010), and trends in climate change and perceptions by farmers (Mulenga and Wineman, 2014). As a result, little empirical research has established the relationship of farmers' adaptation behavior, to the occurrence of extreme weather events.

Several questions arise in light of the possible role of adaptation in risk mitigation from extreme weather events. Do farmers use a variety of strategies to cope with extreme weather events? If this is the case, how are farmers adapting? These answers are critical to help in understanding how

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farmers' respond to weather events that are extreme. Also, help policy makers to design appropriate interventions in local adaptation planning and support policy formulation.

Drought and flood, remain the most severe weather events Zambian farmers face, and as such, the scope of this study is limited to drought and flood events. The novelty of this research is to; (a) find out the adopted adaptation strategies by smallholder farmers, due to climate extremes. (b) provide empirical evidence on the major determinants that influence the choice of adaptation of smallholder farmers' to climate extremes.

2. RESEARCH METHODS

The Study Area

Southern province, one of Zambia's ten provinces, is made up of thirteen districts, and Choma district is its provincial capital. The map of southern province and its districts is shown in Figure 1. The province's overall area is 85,283 km^2, that is, four times the size of Israel. The province is bounded by 16° 30' south and 27° 00' east latitudes. Its plateau is the province's heartland, with the most farmland of any province in Zambia.

Agriculture is the main economic activity in the province. According to CIAT and World Bank (2017), Zambia's main agro-ecological zones include; Region I, Region II and Region III, characterized on the basis of rainfall patterns, types of soil and use of land. Southern province falls in both Region I and Region II. Region I receives annual rainfall of less than 800 mm, with loamy clay soils in the valley and loamy soils on the plateau. The most popular production systems are sorghum, corn, poultry, sheep and goats, cattle, and pigs. As for Region II, it receives 800-1000 mm of annual rainfall on average and crop production is dominated by maize, tobacco, cotton, soybean, sunflower, irrigated groundnuts and wheat. Climate change extremes are most notable in southern province and have thus contributed to low agricultural productivity in the province.

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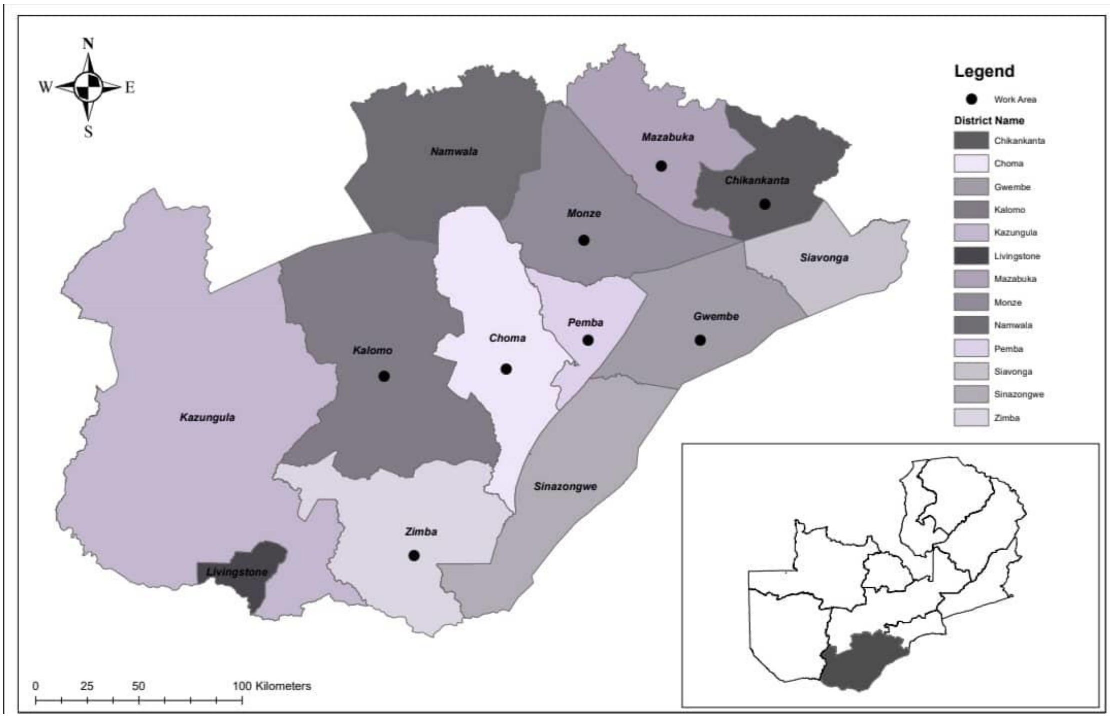

Figure 1. Map of Southern Province.

The dotted points are the location of the work areas.

Source: Zambia Statistics Agency, 2020

Sample Size Determination

We used the following formulae to determine the sample size appropriate for the analysis (Cochran, 1963):

$$n = \frac{z^2(1-p)p}{e^2} \quad (1)$$

Where $z =$ 1.64 (confidence level at 90%), $e =$ 0.05 (margin of error at 5%) and $p =$ proportion of smallholder farmers = 0.5 thus;

$$n = \frac{1.64^2(1-0.5)0.5}{0.05^2} = 270 \text{ smallholder farmers.} \quad (2)$$

Sampling Methods

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This study used only primary data collected in the year 2020, from farm households. The study adopted a "two-stage sampling" technique, used by the "Ministry of Agriculture and Livestock" in Zambia when conducting agriculture surveys.

At the first stage, Standard Enumeration Areas (SEAs) were selected using "probability proportional to Size sampling" and farm households were a measure of size. A SEA is characterized as a section covered by an enumerator during enumeration and contains 100-150 households (Central Statistical Office, 2010). Probability proportional considers each stratum's size and automatically corrects for sample size imbalances, resulting in unbiased and efficient estimates (Turner et al., 2001).

At the second stage, once enumeration areas were selected, enumerators visited and were required to list all households residing in the selected SEAs so as to know the ''total number of households'' residing in the SEAs before choosing a farm household sample.

Within each SEA, a random selection of 20 farm households was conducted. Owing to the sample size of 270 we had, in one SEA, only a random selection of 10 farm households was conducted. These sampled farm households, their crop production suffered, as a result of climate extremes (drought/floods) in the immediate three years (2017, 2018 & 2019) prior to the study. Here, climate extreme was measured according to a farmer's own assessment. By definition, climate extreme took place based on a farmer's indication that their crop output was significantly impacted by climate extreme. If a farmer indicated ''Yes'' then we probed further to find out the years deemed as relatively normal and those where serious climate extreme was experienced. The farmers in the sample deemed 2017 as a "normal year", whereas 2018 and 2019 were deemed as years where "climate extreme" was experienced. Face-to-face interviews were used in this household survey.

Specification of the Econometric Model

In this study, we used a Multinomial Logit Model (MNL), to identify the factors influencing the choice of farmers to a particular adaptation strategy towards climate extremes. The dependent variable was multinomial and had as many categories like the number of adaptation strategies available in the sampled population.

The MNL was chosen because of its analytic and computational tractability (Horowitz et al., 1994). In using the MNL, the parameters were estimated using maximum likelihood. The maximum likelihood estimation approach of the MNL, is not significantly different from binary logit. However,

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the given number of alternatives increases their computational burden (McFadden, 1974). Following the approach by Wittink (2011), the model is specified as follows:

Let y_{in} be the dependent variable and x be a set of independent variables. The dependent variable y_{in} is equal to 1 if a farmer chooses an adaptation alternative (strategy) and 0 otherwise. Further, y_{in} denotes various adaptation alternatives from a given set of adaptation alternatives, and x denotes those factors that influence the choice of the adaptation strategies. The likelihood function is presented as:

$$L = \prod_{n=1}^{N} \prod_{l \in C_n} P_n(i)^{y_{in}}, \quad (3)$$

Following Ben-Akiva and Lerman (1985), the MNL model for the choice probabilities is given by:

$$P_n(l) = \frac{e^{\beta' x_{\ln}}}{\sum_{j \in C_n} e^{\beta' x_{jn}}} \quad (4)$$

It is hypothesized that a farmer's decision on which adaptation strategy to choose from is determined by a vector of independent variables (socioeconomic characteristics and so on). This dependent variable and the independent variable relationship is established by estimating vector of parameters β using log-likelihood method. Rewriting equation 3 above, we obtain a log likelihood function:

$$\log L = \sum_{n=1}^{N} \sum_{l \in C_n} y_{\ln} (\beta' x_{\ln} - \ln \sum_{j \in C_n} e^{\beta' x_{jn}}) \quad (5)$$

Maximizing the log function above and setting its derivative to zero, yields the first order conditions:

$$\sum_{n=1}^{N} \sum_{l \in C_n} [y_{\ln} - P_n(l)] x_{\ln k} = 0, \quad for\ k = 1,\ldots,K. \quad (6)$$

Rewriting the above equation, we obtain;

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$$\frac{1}{N}\sum_{n=1}^{N}\sum_{l\in C_n} y_{\ln} x_{\ln x} = \frac{1}{N}\sum_{n=1}^{N}\sum_{i\in C_n} P_n(l) x_{\ln k},\ \ k = 1,\ldots,K. \tag{7}$$

As a result, the farmer's chosen adaptation strategy has an average value equal to the average value of the estimated choice probabilities. All properties of the maximum likelihood estimation of binary logit extend to the MNL model. This also applies for the computational methods that are used for solving the system of K equations.

The MNL model, requires specifying the base category. This allows a comparison of the probability of membership in other categories to the probability of membership in the base category. Thus, for a dependent variable with j categories, this requires the calculation of $j - 1$ equations, one for each category relative to the base category, to describe the relationship between the dependent variable and the independent variables (Deressa et al., 2009). There are no hard or fast rules in choosing the reference category as it is done arbitrarily albeit theoretically motivated. Based on realistic assumptions, in reality farmers choose more than one adaptation strategies and this implies that the estimated coefficient, in all cases are compared with the base category. 2.5 Choice of Variables and their Measurement

The next section presents the variables (dependent and independent) that were used for this study. Table 1 below provides the list of variables that were used to estimate the empirical model in the study.

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Table 1. Description of Variables

Variable Name	Definition
Dependent variable	
Adaptation	dummy =1 if the farm household adapted to climate extreme, 0 otherwise
Explanatory variables	
Gender (Sex)	dummy =1 if the household head is male, 0 otherwise
Marital Status	dummy =1 if the household head is married, 0 otherwise
Age of Household Head	age of the household head in years
Household Size	total number of persons in the household
Education	highest level of education completed by household head
Farming experience	number of years the head of the household has been farming
Farm Size	total land area owned by a household in hectares
Number of fields owned	total number of fields owned by a household
Plough ownership	dummy=1 if a household owns a plough, 0 otherwise
Oxen ownership	dummy=1 if a household owns oxen, 0 otherwise
Radio ownership	dummy=1 if a household owns a radio, 0 otherwise
Access to extension	dummy=1 if a household had access, 0 otherwise
Source of extension	dummy=1 if extension was provided by a government extension officer, 0 otherwise
Extension services received	total number of extension services received in a season
Distance to Market	distance from homestead to nearest market (km)
Seeds	seeds use per hectare (kg)
Information on expected disasters	dummy =1 if the household received information on expected disasters, 0 otherwise
Information to prevent disasters	dummy =1 if the household received information to prevent disasters, 0 otherwise
Drought	dummy =1 if in previous year(s) drought occurred, 0 otherwise
Flood	dummy =1 if in previous year(s) flood occurred, 0 otherwise

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3. RESULTS AND DISCUSSIONS

In response to climatic extremes (floods and droughts), smallholder farmers adapted the following adaptation strategies (Table 2). Of the sample size of 270 smallholder farmers, about 43 % of them adapted change crop variety as an adaptation strategy to counter climate extremes. Further, soil conservation was adapted by about 24% of the farmers, while crop diversification was adapted by 16%. Farmers also adapted change sow date (11%) and agricultural insurance (6%), to minimize the climate extremes impact on their farming activities. In our study areas, major adaptation strategies include change crop variety, crop diversification, agricultural insurance, soil conservation, and change sow/harvest date. Further analysis indicates that some farmers chose multiple adaptation strategies. Of the famers who adopted more than one adaptation strategy, most adopted two or three adaptation strategies, whereas, fewer than 4% of farmers, adopted four or more adaptation strategies in the reference period.

Table 2. Adaptation Strategies Employed by the Farmers

Percentage of households by types of adaptation strategies adopted (%)	
change crop variety	43.0
soil conservation	24.0
crop diversification	16.0
change sow/harvest date	11.0
agricultural insurance	6.0
	100
Percentage of households by the number of adaptation strategies adopted (%)	
2 adaptation strategies	26.3
3 adaptation strategies	20.4
≥ 4 adaptation strategies	3.3

Source: Study Area

Table 3 below presents the Multinomial Logit estimates of the major factors that influence the choice of farmer’s adaptation strategies given a number of characteristics. Under the multinomial

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model, the dependent variable is multinomial and include the following unordered categories (1 = Change sow/harvest date, 2 = crop diversification, 3 = soil conservation, 4 = agricultural insurance).

The dependent variables in the econometric models truly reflect the adaptation to climate extreme because the sample of the study consisted of farm households who had their crop output affected by climate extremes, in the immediate three years prior to this study. Further, the farmers in the sample, acknowledged that their crop output was significantly impacted by climate extremes in the previous years.

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Table 3. Multinomial Logit Estimates of Adaptation Strategies

	Change Sow/		Crop		Soil		Agricultural	
	Harvest Date		Diversification		Conservation		Insurance	
Explanatory	Coef.		Coef.		Coef.		Coef.	
Variables	(Std. Err.)	dy/dx	(Std. Err.)	dy/dx	(Std. Err.)	dy/dx	(Std. Err.)	dy/dx
Gender	-0.389	-0.057	0.190	-0.007	0.894	0.098*	0.716	0.044
	(0.738)	(0.738)	(0.599)	(0.599)	(0.495)	(0.495)	(0.863)	(0.863)
Marital status	15.835	0.099	-1.998	-0.028**	0.299	0.114	11.362	0.010
	(2.073)	(2.073)	(0.894)	(0.894)	(0.966)	(0.966)	(1.994)	(1.994)
Age of household head	0.024	0.000	0.042	0.002	0.025	0.000	0.146	0.050***
	(0.029)	(0.029)	(0.027)	(0.027)	(0.024)	(0.024)	(0.045)	(0.045)
Household size	0.089	0.004	-0.016	-0.009	0.073	0.007	0.226	0.010
	(0.119)	(0.119)	(0.100)	(0.100)	(0.093)	(0.093)	(0.164)	(0.164)
Education of household head	-0.033	-0.005	0.055	0.003	0.121	0.017*	0.174	0.000
	(0.091)	(0.091)	(0.090)	(0.090)	(0.071)	(0.071)	(0.190)	(0.190)

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Farming experience	-0.035	-0.002*	-0.001	0.000	0.025	0.015**	-0.097	-0.004**
	(0.018)	(0.018)	(0.014)	(0.014)	(0.011)	(0.011)	(0.039)	(0.039)
Farm area owned	0.046	0.008	0.123	0.012*	-0.046	-0.000	-0.227	-0.009
	(0.072)	(0.072)	(0.074)	(0.074)	(0.062)	(0.062)	(0.146)	(0.146)
Number of fields owned	-0.162	-0.009	0.025	0.001	0.123	0.021	0.167	0.004
	(0.206)	(0.206)	(0.193)	(0.193)	(0.128)	(0.128)	(0.350)	(0.350)
Plough ownership	0.111	0.000	0.022	0.037	1.371	0.015*	-0.258	-0.029
	(0.685)	(0.685)	(0.680)	(0.680)	(0.748)	(0.748)	(1.070)	(1.070)
Oxen ownership	-18.508	-0.159	4.929	0.039***	1.809	0.065**	18.033	0.138
	(1.048)	(1.048)	(1.242)	(1.242)	(0.919)	(0.919)	(1.167)	(1.167)
Radio ownership	-0.201	-0.088	0.795	0.056	1.897	0.024***	-0.029	-0.046
	(0.561)	(0.561)	(0.596)	(0.596)	(0.576)	(0.576)	(0.868)	(0.868)
Source of extension	-0.143	-0.032	0.666	0.030	0.861	0.059	2.705	0.097**
	(0.740)	(0.740)	(0.668)	(0.668)	(0.526)	(0.526)	(1.360)	(1.360)
Access to extension	1.547	0.089*	3.123	0.119***	1.279	0.056	17.252	0.125
	(0.738)	(0.738)	(1.213)	(1.213)	(0.845)	(0.845)	(1.167)	(1.167)

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Number of extension services	0.064	0.005	0.178	0.022**	-0.060	-0.012	0.199	0.024*
	(0.091)	(0.091)	(0.083)	(0.083)	(0.101)	(0.101)	(0.116)	(0.116)
Seeds	0.003	0.000	-0.008	-0.000	0.003	0.000	0.004	0.000
	(0.004)	(0.004)	(0.005)	(0.005)	(0.003)	(0.003)	(0.007)	(0.007)
Distance	-0.008	-0.001	0.007	0.001	0.008	0.000	0.063	0.020**
	(0.018)	(0.018)	(0.017)	(0.017)	(0.014)	(0.014)	(0.031)	(0.031)
Information on expected disasters	0.971	0.038	0.289	0.035	0.558	0.055	1.318	0.006)
	(1.380)	(1.380)	(1.314)	(1.314)	(0.930)	(0.930)	(3.214)	(3.214
Information to prevent disasters	1.963	0.127	0.973	0.036	-0.111	-0.158	0.815	0.043
	(1.640)	(1.640)	(1.500)	(1.500)	(1.085)	(0.217)	(3.067)	(3.067)
Constant	-20.459		-5.033		-11.793		-44.376	
	(2073.089)		(3.354)		(2.959)		(2310.911)	

Base outcome Change crop variety

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Number of observations	= 270;	Prob > χ 2 = 0.000
Log likelihood	= -266.924;	Pseudo R^2 = 0.3005; LR chi2 (84) = 229.29

Note: Standard errors appear in parentheses

Asterisks represents level of statistical significance: ***(p ≤ 1%); **(p ≤ 5%); *(p ≤ 10%)

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Gender

The results showed that gender was statistically significant and positively correlated with soil conservation at 10% level. Being male headed household increased the probability of adopting soil conservation as an adaptation strategy by 9.8 %, vis-à-vis the base category. This was so because women do not have much access to land, information and other resources (Abaje et al., 2014). Also, unlike female headed households, households headed by a male are more likely to get information on various farm management practices, new technologies, and how to change them based on available information on climatic conditions and other factors (Deressa et al., 2009).

Marital status

Marital status was negatively and significantly correlated with household decision to adapt crop diversification at 2.8% probability level. This result implied that farm households who were married, had a decreased probability in taking up an adaptation strategy to ease the negative impact of climate extreme.

Age

Age was significant ($p < 0.01$) and significantly increased the likelihood of a farm household adapting agricultural insurance as an adaptation strategy. All other factors being kept constant, increase in the age of a farm household by 1%, lead to a 5% increase in a farm household's likelihood to adapt agricultural insurance. A probable justification is that in the study area, participation in farm activity was higher for older farmers than for younger farmers. The positive impact of age on participation in farm activities implied that, compared to older farm households, young farm households were unable to obtain enough land due to intense population pressure. As a result, the younger households had to depend on non-farm employment to make ends meet.

Education

A positive relationship existed between education and adaptation to climate extreme. Thus the probability of adapting to climate extreme increased with an increase in education of the household head. Further, education significantly increased soil conservation as an adaptation strategy. A 1% increase in the number of school years would result in a 1.7% increase in the probability of a farm household adopting soil conservation to adapt to climate extreme. This implied that further education

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empowered the farm household with an increase in knowledge necessary to make constructive farm decisions about adaptation.

Farming experience

Farmers with a wealth of farming experience have an increased likelihood of adopting adaptation strategy of soil conservation. The results indicate that, a 1% increase in farming experience would increase the probability of a farmer to adapt soil conservation by 1.5 %, *ceteris paribus*. The study results concur with findings of Atube et al., (2021) in a similar study of adaptation. However, farming experience significantly reduced the probability of adapting change sow/harvest date and agricultural insurance by 0.2% and 0.4%, respectively. Thus the probability of adapting change sow/harvest date and agricultural insurance, decreased with farming experience.

Farm size owned

Farm size had a positive and significant impact on household adaptation to climate extremes in the study area. An increase in the size of farm area used by a farm household significantly increased the probability of using crop diversification as an adaptation strategy by 1.2%, *ceteris paribus*. A possible explanation is that in rural areas, agricultural land is a significant source of income and an indicator of wealth. So, large farm sizes enable farmers to produce more and employ some adaptation strategies, thereby distributing risks associated with unpredictable weather.

Asset Plough

As expected, this variable was significant at 10% probability level, and increased uptake of soil conservation, as an adaptation strategy. Farmers who own assets like a plough, had a higher propensity to adapt and invest in adaptation strategies compared to no ownership. This is so because using a plough for tillage, reduces the drudgery that comes with land preparation, reduces manual labor requirement, and allows for a larger land area to be exploited than using a hand hoe.

Oxen ownership

Oxen ownership had a positive impact on farmers likelihood adapting crop diversification and soil conservation as adaptation strategies. Farm households who own oxen had an increased probability in taking up the aforementioned adaptation strategies, by 3.9 and 6.5 units, respectively.

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The results also implied that the key economic activities in the study area were livestock and crop production.

Radio ownership

Radio ownership was an important determinant of adaptation strategy. It significantly increased the likelihood of using soil conservation as an adaptation strategy by 2.4 units at 1% level. This result implied that a radio offers a range of communication techniques that promote agricultural extension activities by communicating directly with farmers using local languages. Also, it enables farmers to access climate change information needed to bridge the knowledge gap between farmers, scientists and policy makers. In a rural setup, radio remains the most available communication source for local communities in the absence of basic services such as internet and electricity due to popularity and least costly.

Extension source

The source of extension service significantly increased the probability of a farm household taking up agriculture insurance as an adaptation strategy. Besides, the probability of farmers who obtained extension services from the government, their participation in agriculture insurance was higher than for farmers who obtained extension services from non-governmental organizations. The results implied that agricultural extension services provided by agricultural offices are an important source of information for improved agricultural productivity. Besides, they help in increasing awareness among farmers about new farming techniques and paving way to increase farm production. According to the information obtained from the Ministry of Agriculture, the number of beneficiaries from extension service is increasing and farmers are gaining a considerable amount of yield increment by employing extension packages.

Access to extension services

It increased the probability of a farm household choosing change sow/harvest date and crop diversification as adaptation strategies, by 8.9 and 11.9 units, respectively. Alternatively, the probability that a household in the study area would adapt the aforementioned adaptation strategies, increased as the household access to extension services increased. This is because farmer's access to

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extension services helps them to build capacities by developing their own technical, organizational and management skills and practices.

Number/Frequency of extension services

This variable significantly determined the probability of a farm household to adapt crop diversification and agricultural insurance as adaptation strategies. This implied that, having frequency of extension services increased the probability of adapting crop diversification by 2.2 % and agricultural insurance by 2.4 %. Extension services received by the farmers, brings about changes in knowledge attitude, skills and aspirations.

Distance to Market

Distance to the market significantly determined the probability of a farm household to participate in adapting to climate extremes. A 1% increase in distance to the market, significantly increased the farmer's probability of participating in adaptation by 2% – that is, the further a farmer was from the market, the more likely they would adapt agricultural insurance as an adaptation strategy. The results implied that farming households located farther from the nearest market would adapt for food security due to higher transport costs in accessing market incentives to adapt for commercial purposes. A previous study by Khanal et al. (2018), indicate that distance to the market influences adoption of adaptation strategies by farm households. Also, Leones and Feldmans (1998) confirms that participation in non-farm activities is stimulated by proximity to market center.

4. CONCLUSION

This study identified the various adaptation strategies employed by farmers towards climate extremes. The common adaptation strategies adopted by the farmers to minimize climate extremes impact on their farming activities were; change crop variety, agricultural insurance, change sow/harvest date, crop diversification and soil conservation. Further analysis indicates that some farmers chose more than one adaptation strategy. In addition, the multinomial logit model was used in identifying the major determinants influencing smallholder farmers' choice of adaptation strategies to climate extremes.

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In light of the findings above, the study recommends that; when drafting policy, asset formation of the farmers should be considered, and government should undertake policies that will improve farmers' access to agricultural assets (plough, oxen etc). Further, the need at local levels to increase farmers education and awareness of climate extreme through extension services. The government should embrace policies that provide land ownership to farmers and ensure that tenure arrangements are safeguarded. Lastly, policymakers should acknowledge farming experience and draw on knowledge and experience from local community-level in the process of policy formulation.

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