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Modelling Determinants of Farmers' Choice of Adaptation Strategies to Climate Variability and Extreme Events in Kitui County, Kenya

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***Abstract*—*The study was carried out to assess determinants of farmers' choice of specific adaptation strategies to climate variability and extreme events in selected agro-ecological zones in Kitui County. Descriptive survey design was used. The study area was stratified into four study sites with respect to four different agro-ecological zones and a total of 341 households selected to constitute the sample size. Multivariate probit regression model was run in Stata version 12 to determine the influence of different socio-economic characteristics on farmers' choice of specific adaptation strategies. The model results indicated that age, gender, farming experience, membership to farmers' organization, education level, access to extension services and proximity to market had a significant varying influence on farmers' choice of several adaptation strategies. The study established that different socio-economic characteristics had a different influence on the farmers' choice of specific adaptation strategies. The study therefore recommends that climate variability adaptation policies, programs and projects by governmental and non-governmental development agencies should target specific socio-economic characteristics that are relevant to the adaptation strategies in question.*

***Keywords*—Socio-economic characteristics, multivariate probit regression, agro-ecological zones, adaptive capacity.**

I. INTRODUCTION

Changes in the climate system in recent decades have caused significant impacts on the natural and human systems on all continents and across the oceans (IPCC, 2014). According to IPCC (2007), variability in temperature and rainfall patterns have been predicted to cause significant effects on global agriculture, due to extreme weather events such as droughts and floods and changes in patterns of pests and diseases. The effects of changing temperature and rainfall patterns are more pronounced in developing countries owing to their geographic exposure, low income, greater reliance on rain-fed agriculture and other climate sensitive sectors coupled with its weak capacity to adapt to the changing climate (Belloumi, 2014; Thomas et al., 2005; Slingo et al., 2005).

The IPCC (2007) report estimated that Africa will be the most vulnerable continent to the progressive changes in climate globally, due to its low adaptive capacity resulting from the multiple stresses of poor infrastructure, poverty and governance. Kenya is one of the most vulnerable countries to climate variability and extreme events in Africa due to its low adaptive capacity and dependence on climate-sensitive sectors such as agriculture and fisheries as the key drivers of its economy (FAO, 2011; Herrero et al., 2010;

Kurukulasuriya et al., 2006; Kabubo-Mariara and Karanja, 2007). Climatic variability is therefore expected to have adverse effects in Kenya's economy because of her dependency on climate sensitive natural resources, and thus recurring droughts, erratic rainfall patterns and floods will continue to negatively impact livelihoods and community assets (Government of Kenya, 2016).

Since agriculture is the mainstay of most rural communities in Kenya (Republic of Kenya, 2005) negative developments in agriculture would adversely affect the rest of the livelihoods that are depended on agricultural production. The cumulative effects of climate variability and extreme events in Kenya therefore pose a significant threat towards the attainment of the country's Vision 2030 (Parry et al., 2012) as well as the implementation of the Sustainable Development Goals (UNECA, 2018; UNCCS, 2017). Implementation of adaptation strategies will therefore be paramount to cushion communities from the effects of climate variability and extreme events and promote sustainable livelihoods in the advent of a changing climate (Akinnagbe and Irohibe, 2014; Schipper et al., 2008; IPCC, 2007).

According to Maddison (2006), the ability and decision to adopt a particular adaptation strategy is determined by several institutional and socio-economic factors. In the face of climatic variability, farmers may opt to adopt several strategies instead of relying on a single strategy to exploit complementarities or substitutability among alternatives (Ojo and Baiyegunhi, 2018). The current study therefore sought to examine the determinants of farmers' choice of specific adaptation strategies in different agro-ecological zones in Kitui County.

II. MATERIALS AND METHODS

2.1 Profile of the study area

The study was carried out along a transect line (in a buffer zone of 5km radius on both sides of the line) in semi-humid, transitional semi-humid to semi- arid, semi-arid and arid zones in Kitui County. The study sites are shown in Fig. 1.

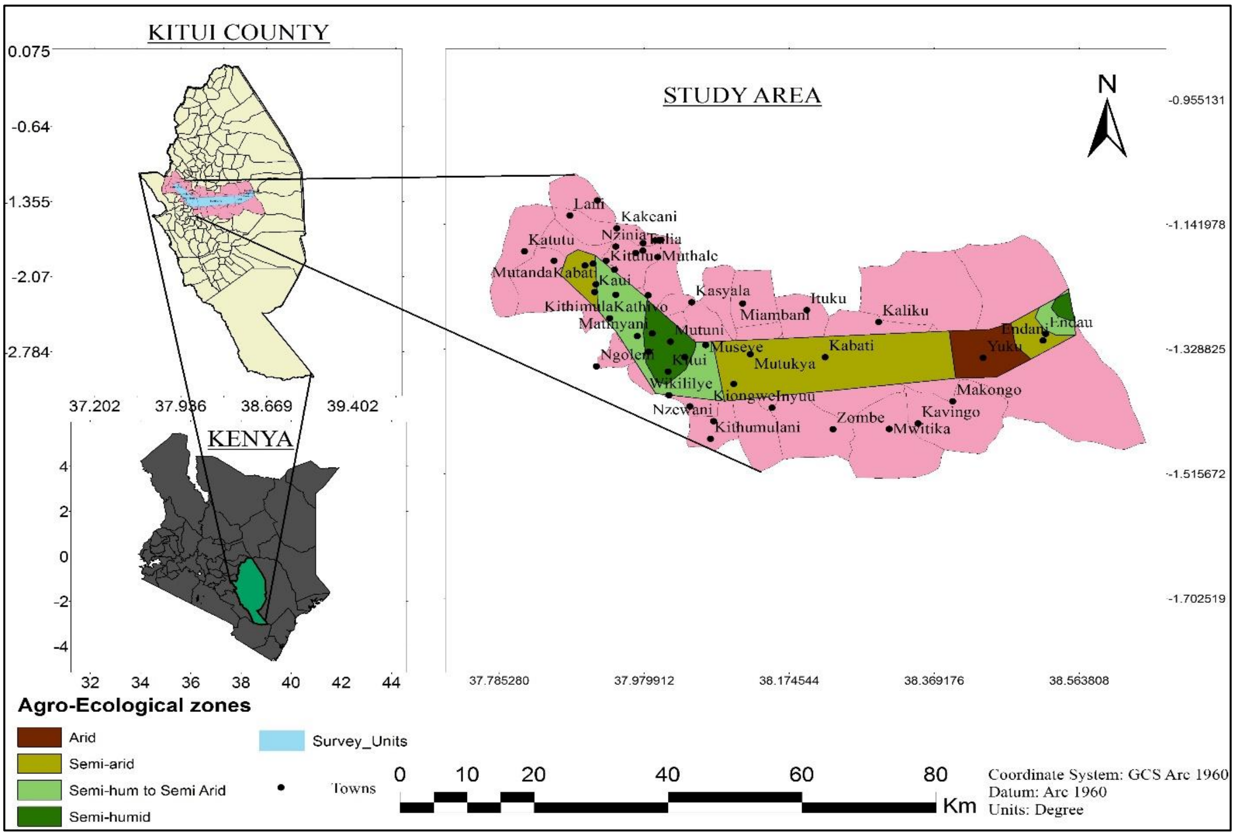

Fig.1: Map of Kitui County showing the study area in four agro-ecological zones

Source: ILRIS GIS Database

Kitui County lies between 400m to 1,830m above sea level and generally slopes from the west to east with the highest regions being Kitui Central and Mutitu Hills (KCIDP, 2018). The climate of the area is semi-arid with very erratic and unreliable rainfall. The area is hot and dry throughout the year with temperatures ranging from a minimum of 14-22° centigrade to a maximum of 26-34° centigrade. The months of February and September are the hottest months in the year (KCIDP, 2018). Rainfall is distributed within two seasons annually and varies from 500-1050mm with about 40% reliability. The long rains are experienced between March and May and short rains between October and December. The short rains are considered more reliable than the long rains since it is during the short rains that farmers get their main food production opportunity (NDMA, 2017).

The soil types range from red sandy soils, to clay black cotton soils which are generally low in fertility (Republic of Kenya, 2005). The County's population is approximately 1,136,187 according to the population and housing census report of 2019 (Government of Kenya, 2019). Livestock production and crop farming are the back bone of the people's economy in the area contributing to nearly three quarters of the household earnings (KCIDP,2018; Republic of Kenya, 2005). The main livestock types kept in the County are cattle (beef and dairy), goats (meat and dairy), sheep and poultry (indigenous and exotic) (KCIDP, 2018). Various crops such as maize, beans, sorghum, pigeon peas, millet and cassava are cultivated mainly for subsistence while green grams, sweet potatoes, vegetables such as tomatoes, kales, spinach, pawpaw, onions and fruits (mangoes, bananas, water melons) are grown for sale and household consumption (KCIDP, 2018; NDMA, 2017; Republic of Kenya, 2005).

2.2 Study Design and Sampling Techniques

Descriptive survey design was used. The target population for the study was the agro-pastoral farmers in the study area. The unit of study was the household while the respondents comprised of the head of the households. Stratified sampling method was used to classify the study sites with reference to four different agro-ecological zones in Kitui County. One sub-location in each agro-ecological zone was randomly selected along a transect line (in a buffer zone of 5km radius on both sides of the line). Systematic random sampling method was used to identify respondents in the selected sub-location.

The sample size for the study was determined by calculating 10% of the number of households in each of the four sub-locations. According to Mugenda and Mugenda (2003), a sample size of 10% provides an adequate representation of the target population in descriptive research. The total sample size for the study was 341 households with 39,160, 38 and 104 households from the arid, semi-arid, transitional semi-arid to semi-humid and the arid zones, respectively.

2.3 Data Collection and Analysis

Primary data was collected through administration of questionnaires to 341 respondents. Interviews with key informants were also conducted. Multivariate Probit (MVP) regression model was run in Stata version 12 to assess the determinants of farmers' choice of different adaptation strategies in the study area.

The MVP decision model is guided by the random utility theoretical model which describes a choice decision in which an individual has a set of alternative adaptation strategies from which to choose (McFadden, 1978). The model assumes that each adaptation option has distinct attributes that influence a farmer's choice over another alternative and is based on the notion that the utility is derived by choosing several alternatives.

The utility random model is described below as applied by Feleke et al. (2016).

Assuming that U_j is the expected utility that a farmer will gain from using adaptation strategy j whereas U_k is the expected utility for not choosing adaptation strategy j but rather k.

The linear random utility model of adapting to climate variability by choosing j_{th} adaptation strategy (U_j) can be expressed as a function of explanatory variables X_i as shown below:

$$U_{ij} = x_i\beta_j + \mu_j \quad (1)$$

The linear random utility model for i_{th} farmer who does not use j_{th} adaptation strategy but rather k_{th} adaptation strategy is given by:

$$U_{ik} = x_i\beta_k + \mu_k \quad (2)$$

Where x_i is a vector of explanatory variables β_j and β_k are vectors of parameters for choosing j_{th} and k_{th} adaptation strategy respectively, μ_j and μ_k are error terms for choosing j_{th} and k_{th} adaptation strategy, respectively. According to Gujarati (2006), the error terms in the above equations are assumed to be normally independently and identically distributed.

If a farmer chooses to adopt j_{th} adaptation strategy to climate variability, then the expected utility that the farmer gets is greater than the expected utility for not using that strategy and according to Falco et al. (2011), a farmer chooses adaptation strategy j over adaptation strategy k if and only if the expected utility from adaptation strategy j is greater than that of k as expressed in equation 3:

$$U_{ij} = x_i\beta_j + \mu_j > U_{ik} = x_i\beta_k + \mu_k \quad (3)$$

Following Mihiretu et al. (2019) and Piya et al. (2012), the MVP model assumes that each subject has J distinct binary responses. Let i=1,...n be the independent observations, j=1,...J be the available options of binary responses, and X_i be a matrix of covariates composed of any discrete or continuous variables.

Let $Y_{ij} = Y_{i1} \dots Y_{ij}$ denote the J-dimensional vector of observed binary responses taking values {0;1} on the i^{th} household and $Z_{ij} = Z_{i1} \dots Z_{ij}$ denote a J-variate normal vector of latent variables such that:

$$Z_{ij} = X_{i\beta} + \varepsilon_i 1 = 1 \dots n \quad (4)$$

where $\beta = \beta_1 \dots \beta_j$ is a matrix of unknown regression coefficient, ε_i is a vector of residual error distributed as multivariate normal distribution with zero means and unitary variance;

$$\varepsilon_i \sim N(0, \Sigma),$$

where Σ is the variance-covariance matrix.

The off-diagonal elements in the correlation matrix, $\rho_{kj} = \rho_{jk}$ represent the unobserved correlation between the stochastic components of k^{th} and J^{th} options (Cappellari and Jenkins, 2003).

The relationship between Z_{ij} and Y_{ij} is:

$$Y_{ij} = \{1\ if > 0; 0\ otherwise\} i = 1 \dots n\ and\ j = 1 \dots J \quad (5)$$

The likelihood of the observed discrete data is then obtained by integrating over the latent variables:

$$Z: P(Y_{ij} = {}^1/_{X_i\beta\Sigma}) \int A_{i1} \Phi_T (Z_{ij} = {}^1/_{X_i\beta\Sigma}) dZ_{ij} \quad (6)$$

Where, A_{i1} is the interval (0, ∞) if Y_{ij}=1 and the interval (-∞, 0) otherwise and

$A_{i1}\Phi_T(Z_{ij} = {}^1/_{X_i\beta\Sigma})dZ_{ij}$ is the probability density function of the standard normal distribution.

Since the coefficient estimates from MVP regression show the direction of influence rather than the magnitude (Mullahy, 2017), to interpret the effects of explanatory variables on the probabilities, marginal effects were derived as follows:

$$\partial ij = \frac{\partial Pij}{\partial x_i} Pij \left[\beta j - \sum_{k=0}^{j} P_{kj}\,\beta_k\right] = P_{ij}[\beta j - \beta] \ (7)$$

where, δij-denotes the marginal effect of the explanatory variable on the probability that alternative j is chosen. The marginal effects measure the expected change in probability of a particular choice with respect to a unit change in an explanatory variable (Amdu et al., 2012).

The multivariate probit (MVP) regression model was chosen for this study since it simultaneously models the influence of the set of explanatory variables on each of the adaptation strategies, while allowing the unobserved factors (error terms) to be freely correlated (Belderbos et al., 2004; Lin et al., 2005). According to Belderbos et al. (2004), the source of correlation may be complementarities (positive correlation) and substitutability (negative correlation) between different adaptation strategies.

For the purpose of this model, selected adaptation strategies to climate variability and extreme events adopted by farmers were used as the dependent variables while farmers' socio-economic characteristics were used as the explanatory variables for the model as described in Table 1 and Table 2, respectively.

Table 1 Description and summary statistics of dependent variables used in the Multivariate Probit model

Dependent variables (Adaptation Strategies)	**Description of Variables**	**Mean**	**SD**
Crop diversification	Dummy=1 if household adopts crops diversification, 0=otherwise	0.70	0.46
Planting drought resilient crops	Dummy=1 if household adopts planting drought resilient crops, 0=otherwise	0.66	0.47
Planting hybrid crop varieties	Dummy=1if household adopts planting hybrid crop varieties, 0=otherwise	0.60	0.49
Use of soil conservation techniques	Dummy=1if household adopts soil conservation techniques, 0=otherwise	0.72	0.45
Use of inorganic fertilizers	Dummy=1if household adopts use of fertilizers, 0= otherwise	0.27	0.46

Use of manure	Dummy=1if household adopts use of manure, 0=otherwise	0.81	0.40
Agroforestry	Dummy=1if household adopts agroforestry, 0=otherwise	0.47	0.50
Use pesticides	Dummy=1if household adopts use of pesticides, 0=otherwise	0.72	0.45

Table 2 Description and summary statistics of explanatory variables used in theMultivariate Probit Model

Variable	**Description**	**Mean**	**SD**	**Expected sign**
X_1	Gender of household head (1= male; 0= female)	1.29	0.46	+/-
X_2	Age of the household head (number of years of the household head)	55.86	15.11	+/-
X_3	Household size (number of family members in the household)	5.88	2.64	+/-
X_4	Membership in a farmers' cooperative/group (1= yes; 0= otherwise)	0.20	0.40	+
X_5	Farming experience (number of years household head involved in farming)	25.66	16.52	+
X_6	Education level of the household head (years of schooling of the household head)	12.43	4.41	+
X_7	Access to credit (1= yes; 0= otherwise)	0.35	0.48	+
X_8	Access to extension services (1=yes, 0=otherwise)	0.20	0.40	+
X_9	Distance from the market (how far the household is from the market in Km)	2.79	3.24	+
X_{10}	Access to early warning weather information (1=yes, 0=otherwise)	0.74	0.44	+
X_{11}	Land size(Number of acres owned by the household)	5.82	8.07	+/-

III. RESULTS

3.1 Determinants of farmers' choice of specific adaptation strategies to climate variability and extreme events in the study area

The coefficient estimates of the multivariate probit model are presented in Table 3. The null hypothesis for test of independence in the model was rejected since the likelihood ratio test (*Log likelihood = -1394.05*; Prob > $\chi 2$ = 0.00) of independence of error terms was significant implying that there is a mutual interdependence among the adaptation strategies and thereby justifying the use of multivariate probit regression model in assessing the determinants of farmers' choice of different adaptation strategies as it captures wider effects than a univariate probit model could obtain.

The pairwise correlation coefficients (Rho) shown in Table 3 also indicated a positive correlation between the pairs most of which are highly significant implying that the sets of adaptation strategies are complimentary. Variance inflation factor (VIF) values for all the explanatory variables were between 1 and 3 implying that multicollinearity was not a concern since according to Yoo et al. (2014), multicollinearity concerns exist when the VIF value is greater than 10.

Table 3 Coefficient estimates of Multivariate Probit regression results on determinants of farmers' adoption of specific adaptation strategies in the study area

Explanatory variables	**Dependent Variables**							
	Crop diversification	**Drought resilient crops**	**Hybrid crop varieties**	**Soil conservation techniques**	**Use of fertilizer**	**Use of manure**	**Agroforestry**	**Use of Pesticides**
Age	-0.02 (0.01)**	-0.01 (0.01)	-0.00 (0.01)	-0.02 (0.01)**	-0.00 (0.00)	0.00 (0.01)	-0.01 (0.01)*	-0.01 (0.01)
Gender	0.32 (0.18)**	0.20 (0.17)	-0.11 (0.17)	0.25 (0.19)*	-0.46 (0.18)***	0.30 (0.19)*	0.25 (0.16)*	-0.37 (0.17)**
Household size	-0.05 (0.03)	0.04 (0.03)	-0.03 (0.03)	-0.06 (0.03)**	-0.01 (0.03)	0.00 (0.03)	-0.04 (0.03)	-0.03 (0.03)
Farmers' group membership	0.16 (0.23)	-0.31 (0.21)	-0.42 (0.21)**	0.57 (0.27)**	-0.09 (0.22)	-0.42 (0.24)*	0.21 (0.21)	0.27 (0.24)
Farming experience	0.01 (0.01)*	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)*	0.00 (0.01)	-0.01 (0.01)	0.01 (0.01)	0.00 (0.01)
Education level	-0.00 (0.17)	0.02 (0.02)	0.07 (0.02)***	0.06 (0.02)***	0.01 (0.17)	0.06 (0.02)***	0.05 (0.02)***	0.05 (0.02)**
Access to credit	0.19 (0.17)	0.30 (0.16)*	0.08 (0.16)	-0.01 (0.17)	0.05 (0.16)	0.14 (0.19)	0.04 (0.15)	0.15 (0.17)
Access to extension services	0.17 (0.23)	0.51 (0.23)**	-0.30 (0.21)	0.43 (0.26)*	0.31 (0.21)*	0.34 (0.26)	0.41 (0.21)**	0.28 (0.23)
Distance to market	-0.03 (0.02)*	-0.02 (0.02)	-0.13 (0.03)***	-0.06 (0.02)***	-0.04 (0.03)*	0.01 (0.40)	-0.02 (0.02)	-0.09 (0.03)***
Access to weather information	-0.37 (0.18)	-0.11 (0.17)	-0.04 (0.17)	-0.38 (0.19)	0.27 (0.19)	-0.10 (0.19)	0.15 (0.16)	-0.07 (0.17)
Land size	0.01 (0.01)	0.03 (0.01)**	-0.00 (0.01)	0.01 (0.01)	-0.03 (0.01)**	-0.00 (0.01)	-0.01 (0.01)	-0.02 (0.02
Constant	1.18 (0.45)***	-0.10 (0.43)	0.47 (0.43)	0.91 (0.47)**	-0.45 (0.46)	-0.08 (0.48)	-0.52 (0.43)**	0.91 (0.46)**
	Rho 1	**Rho 2**	**Rho 3**	**Rho 4**	**Rho 5**	**Rho 6**	**Rho 7**	**Rho 8**
Rho 2	0.30 ***							
Rho 3	0.29***	0.19***						

Rho 4	0.01	0.10*	0.14*					
Rho 5	0.50***	0.31***	0.21***	0.08*				
Rho 6	0.01	0.13*	0.25***	0.16***	0.05			
Rho 7	0.26***	0.08*	0.13***	0.19***	0.24***	0.11**		
Rho 8	0.31	0.10*	0.28***	0.06	0.32***	0.10*	0.31***	

*Number of observations = 341; Wald chi^2 (88) = 204.71; Log likelihood = -1394.05; Prob > chi2 = 0.00; Figures in parentheses are standard errors; ***, **, * significant at 99%, 95% and 90% confidence levels, respectively.*

The marginal effects presented in Table 4 were used to quantify the influence of explanatory variables on the dependent variables in the model.

Table 4 Marginal effects of explanatory variables on dependent variables

Explanatory variables	**Dependent Variables**							
	Crop diversification	**Drought resilient crops**	**Hybrid crop varieties**	**Soil conservation techniques**	**Use of fertilizer**	**Use of manure**	**Agroforestry**	**Use of pesticides**
Age	-0.01 (0.05)**	-0.01 (0.01)	0.01 (0.01)	0.08 (0.05)	0.00 (0.00)	0.00 (0.00)	-0.01 (0.01)**	-0.01 (0.01)
Gender	0.12 (0.04)**	0.07 (0.06)	0.04 (0.06)	-0.01 (0.01)**	-0.15 (0.06)***	0.07 (0.05)*	0.09 (0.16)*	-0.11 (0.01)**
Household size	-0.02 (0.06)*	0.01 (0.01)	-0.01 (0.01)	-0.02 (0.01)**	-0.01 (0.01)	0.01 (0.01)	-0.02 (0.01)	-0.01 (0.01)
Farmers' group membership	0.06 (0.44)	-0.11 (0.07)	-0.13 (0.07)	0.17 (0.07)**	-0.01 (0.07)	-0.10 (0.06)*	0.08 (0.08)	0.08 (0.07)
Farming experience	0.01 (0.01)**	0.01 (0.01)*	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	-0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Education level	-0.01 (0.01)	0.01 (0.01)	0.02 (0.01)***	0.01 (0.01)***	0.01 (0.01)*	0.02 (0.01)***	0.02 (0.01)***	0.01 (0.01)**
Access to credit	0.05 (0.05)	0.09 (0.05)*	0.03 (0.05)	0.01 (0.05)	0.01 (0.05)	0.03 (0.05)	0.00 (0.00)	0.04 (0.05)
Access to extension services	0.06 (0.07)	0.17 (0.08)**	-0.11 (0.07)	0.10 (0.07)	0.09 (0.07)	0.08 (0.07)	0.16 (0.07)**	0.09 (0.07)
Distance to market	-0.01 (0.06)*	-0.01 (0.01)	-0.05 (0.01)	-0.02 (0.01)***	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.04 (0.01)***
Access to weather information	-0.12 (0.01)	-0.03 (0.06)	-0.01 (0.06)	-0.10 (0.05)	0.01 (0.01)	-0.02 (0.05)	0.06 (0.06)	0.05 (0.05)

Land size	0.01 (0.01)	0.01 (0.01)**	-0.01 (0.01)	0.01 -(0.01)	-0.01 (0.01)	$7.84e^{-06}$ (0.00)	-0.01 (0.01)	0.01 (0.00)

The multivariate probit regression results indicated that age of the household head had a positive but insignificant influence on the adoption of use of manure. There was however a negative influence of age of the household head on the adoption of crop diversification, planting drought resilient crops, planting hybrid crop varieties, soil conservation techniques, agroforestry and use of pesticides. The negative influence of age of the household head was significant on the adoption of crop diversification, soil conservation techniques and agroforestry. Marginal effects results showed that a unit increase in age reduced the probability of adopting crop diversification, soil conservation techniques and agroforestry by a factor of 0.01, 0.08 and 0.01, respectively.

Gender of the household head had a positive influence on the adoption of crop diversification, drought resilient, soil conservation techniques, use of manure and agroforestry which was significant on the adoption of crop diversification, use of manure and agroforestry. The marginal effects results indicated that male headed households were 12%, 7% and 9% more likely to adopt crop diversification, use of manure and agroforestry, respectively than their female counterparts. In regards to the adoption of use of fertilizers and pesticides, gender of the household head had a significant negative influence with marginal effects of 0.15 and 0.11, respectively. This implies that female headed households were 15% and 11% more likely to use fertilizers and pesticides, respectively than their male counterparts. The results indicated a positive but insignificant influence of household size on the adoption of drought resilient crop varieties. A negative influence of household size was however noted on the adoption of crop diversification, hybrid crop varieties, soil conservation techniques, agroforestry and use of pesticides and fertilizers with the influence being significant only on the adoption of soil conservation techniques with a marginal effect of 0.02. This implies that a unit increase in household size reduced the probability of adopting soil conservation techniques by 2%.

Membership in a farmers' organization had a negative insignificant influence on the adoption of drought resilient crops, hybrid crop varieties, manure and fertilizers. There was however a positive influence on the adoption of crop diversification, soil conservation techniques, pesticides and agroforestry. The significant negative influence of membership in a farmers' organization had a marginal effects 0.13 implying that membership to farmers' organization decreased the probability of adopting hybrid crop varieties by 13%. On the other hand, membership in a farmers' organization significantly increased the probability of adopting soil conservation techniques by 17%.

The results indicated that farming experience had a positive influence on all the adaption strategies except for adoption of use of manure, which was negative but insignificant. The positive influence of farming experience was significant on the adoption of crop diversification and soil conservation techniques with marginal effects of 0.01 on each, implying that a unit increase in farming experience increased the probability of adopting crop diversification and soil conservation techniques by 1%.

Further, the results indicated that education level of the household head had a positive influence on the adoption of all the strategies except for crop diversification. The results indicated a statistically significant positive influence on the adoption of use of hybrid crop varieties, soil conservation techniques, use of manure, agroforestry and use of pesticides with marginal effects of 0.02, 0.01, 0.02, 0.02 and 0.01, respectively. The results implied that a unit increase in education level of the household head increased the probability of adopting hybrid crop varieties, soil conservation techniques, use of manure, agroforestry and use of pesticides by 2%, 1%, 2%, 2% and 1%, respectively.

Access to credit facilities had a positive influence on the adoption of all the strategies except for soil conservation techniques. The influence of access to credit facilities was significant on the adoption of drought resilient crops with a marginal effect of 0.09 implying that farmers with access to credit facilities were 0.09 more likely to adopt drought resilient crops than those without access to credit facilities.

In regards to access to extension services, a positive influence was noted on the adoption of all the adaption strategies except for use of hybrid crop varieties. The results indicated a significant positive influence on the adoption of drought resilient crops, soil conservation techniques, use of fertilizers and agroforestry. The marginal effects results indicated that access to extension services increased the farmers' probability of adopting the drought resilient crops, soil conservation techniques, use of fertilizers and agroforestry by 17%, 10%, 9% and 16 %, respectively. Access to weather information however had an insignificant negative influence on the adoption of all the adaptation strategies except for the use of fertilizers and agroforestry.

The results further indicated that distance to market had a negative influence on the adoption of all the adaption strategies except for use of manure implying that ease of access to the market increased farmers probability of adopting the different adaption strategies. The negative influence of distance to market was significant on adoption of crop diversification, use of hybrid crop varieties, soil conservation techniques, fertilizers, agroforestry and pesticides whose marginal effects implied that a unit increase in distance to the market reduced farmers' probability of adopting crop diversification, use of hybrid crop varieties, soil conservation techniques, fertilizers, agroforestry and pesticides by a factor of 0.01, 0.05, 0.02, 0.01, 0.01 and 0.04, respectively.

The influence of land size was positive on the adoption of crop diversification, drought resilient crops and soil conservation techniques. There was however a negative influence of land size on the adoption of hybrid crop varieties, use of fertilizers, manure, agroforestry and pesticides. A significant influence of land size was noted on the adoption of drought resilient crops and use of fertilizers implying that an increase unit in land size increased the probability of adopting drought resilient crops while decreasing that of adopting use of fertilizers by 1%.

IV. DISCUSSION

The ability and decision to adopt a particular adaptation strategy is determined by several socio-economic factors (Maddison, 2006). Results from the present study indicated that different socio-economic characteristics of farmers had a different influence on the farmers' choice of specific adaptation strategies to climate variability and extremes. The results showed that there was a significant negative influence of age on the adoption of crop diversification, soil conservation techniques and agroforestry which implies that younger farmers in the study area were more likely to adopt the adaptation strategies as compared to older farmers. This could be because younger farmers are innovative and likely to try new technologies and methods to improve agricultural productivity. Conversely, in most cases older farmers are often not aware of recent innovations in agriculture and/or are reluctant to try new methods. Similar findings where there was a significant negative influence of age on the adoption of mixed cropping and improved crop varieties were reported in other studies (Ojo and Baiyegunhi, 2018; Ali and Erenstein, 2016).

With regards to gender of the household head, female headed households were more likely to use fertilizers and pesticides compared to their male counterparts. This could be attributed to the fact that female headed households have less access to resources such as land and therefore resort to invest in use of fertilizers and pesticides to boost their agricultural productivity in their small pieces of land. On the other hand, the results indicated that male headed households were more likely to adopt crop diversification, use of manure and agroforestry as opposed to female households. This could be because women-headed households are usually constrained by family labor since they are culturally assigned responsibility in domestic activities and also have less access to resources and information compared to male headed households which limit their ability to carry out labor-intensive activities. The easiness with which male headed households adapt to climate change compared to female headed ones was also highlighted by Tenge De Graffe and Heller (2004) while working on the social and economic factors that influence adoption of soil and water conservation (SWC) measures in the West Usambara highlands, Tanzania. Further, Deressa et al. (2009) noted that male headed households are more likely to have access to technologies and climate change information than female-headed households and therefore better placed in adopting diverse adaptation strategies than female- headed households. In addition, Mihiretu et al. (2019), Asrat and Simane, (2018) and Belay et al. (2017) also reported that male-headed households had a higher probability of adopting new agricultural technologies compared to their female counterparts. The results of the current study are however contrary to findings by Nhemachena and Hassan (2007) who noted that female-headed households in Southern Africa were more likely to take up climate change adaptation practices since they are responsible for much of the agricultural work in the region and therefore have greater experience and access to information on various management and farming practices.

The negative influence of household size noted on the adoption of soil conservation techniques could be explained by the fact that since not all members in the family are actively engaged in agricultural activities, a bigger household size would increase demand for resources thereby diverting family labor to off-farm jobs to supplement households' food and economic needs. The results are in agreement with findings from Arun and Yeo (2019) who reported a negative influence of household size on farmers' adoption of adaptation strategies such as crop irrigation, changing of crop date crop type, and crop varieties. In their study, Dumenu and Tiamgne (2020) also noted that a household with more dependents was more likely to direct a larger proportion of its resources towards the household's welfare leaving it with little resources for adapting to climate change and variability thereby increasing its vulnerability to climate variablilty and extremes. Similarly, Tizale (2007) found that there was a possibility that households with large families diverted part of their labour to non-farm activities to earn income to ease the consumption pressure imposed by a large family. The results however contradict findings from similar studies by Asrat and Simane (2018), Belay et al. (2017) and Jiri et al. (2015) who noted a positive influence of household size on adoption of labour intensive adaptation strategies.

From the study, membership in a farmers' organization reduced farmers' probability of adopting hybrid crop varieties. Discussions with farmers and key informants from relevant institutions revealed that high cost of hybrid crop varieties discouraged households from adopting the strategy thus gaining knowledge about the hybrid crop varieties without financial facilitation from the organizations was not adequate in enabling farmers to adopt the strategy. It was however noted that membership in a farmers' organization significantly increased the probability of adopting soil conservation techniques. This could be because farmers' organizations in form of cooperatives, self-help groups or market groups function as sources of information, learning platforms and social support systems that are critical in creating linkages with other actors, providing space for knowledge generation and sharing, discussion of innovation and information necessary in adapting to changes in climatic conditions. The current trend of results is concurrent with findings of similar studies (Borda-Rodriguez and Vicari, 2015; Kearney and Berkes, 2007). In addition, studies by Kangogo et al. (2020), Žurovec and Vedeld (2019) and Bryan et al. (2011) indicated that farmers belonging to farmers' organizations were more likely to adopt different adaption strategies since social networks facilitate information flows through discussion of problems, sharing new innovations and technologies as well as taking collaborative decisions which enhance their capacity to adapt to climate variability and extreme events.

Farming experience of the household head was found to have a positive influence on the adoption of crop diversification and soil conservation techniques. This can be ascribed to the fact that experienced farmers have high skills in farming techniques and management and are able to spread risk when facing climate variability and extreme events by exploiting strategic complementarities in different adaptation strategies. The results are in agreement with findings from similar studies by Asrat and Simane (2018) and Belay et al. *(*2017) who noted a positive influence of farming experience on the adoption of several adaptation strategies. Further, the current trend of results corroborates findings of similar work by Nhemachena and Hassan (2007).

The education level of the household head increased the probability of adopting hybrid crop varieties, soil conservation techniques, use of manure, agroforestry and use of pesticides. This could be attributed to the fact that educated farmers are more likely to perceive changes in climatic conditions, better recognize the risks associated with the climatic changes and have better reasoning capability and awareness about new technologies. The results are in consonance with findings from similar studies (Asrat and Simane, 2018; Fagariba et al., 2018; Belay et al., 2017; Deresa et al., 2009 and Nhemachena and Hassan, 2007).

Access to credit facilities had a positive influence on the adoption of all the strategies except for soil conservation techniques. The results imply that access to credit facilities increased the probability of farmers to adopt different adaptation strategies. Accordingly, access to credit facilities increases farmers' financial capacity to meet transaction costs associated with several adaptation strategies. The results are in agreement with findings from similar studies by Arun and Yeo (2019), Fagariba et al. (2018) and Tesfaye and Seifu (2016) who noted a positive relationship between access to credit facilities and adoption of different adaptation strategies.

In regards to access to extension services, the results indicated a significant positive influence on the adoption of drought resilient crops, soil conservation techniques, use of fertilizers and agroforestry. This is because agricultural extension services provide farmers an opportunity to acquire information and trainings on climatic variations, new technologies and innovations as well as new skills and technical capacity for sustainable implementation of adaptation strategies. The results are in agreement with findings from similar studies which reported a positive influence of access to extension services on farmers' adoption of different adaptation strategies (Teklewoldet al., 2019; Fagariba et al., 2018; Belay et al., 2017 and Nhemachena et al., 2014).

Contrary to the expectation, access to weather information had an insignificant negative influence on the adoption of all the adaptation strategies except for the use of fertilizers and agroforestry. Similar studies noted that access to weather information increases farmers awareness on climatic changes which is essential in making informed decisions on preparedness to reduce agricultural losses that might occur from climate variability and extreme events thereby increasing the probability of farmers' to adopt different adaption strategies (Asrat and Simane, 2018; Fagariba et al., 2018; Belay et al., 2017; Nhemachena et al., 2014). The negative influence of access to weather information on adoption of the different adaptation strategies in this study could suggest that farmers are more likely to invest in off-farm livelihood options as opposed to agriculture upon noting the possibility of occurrence of extreme weather events.

The results further indicated that distance to market had a negative influence on the adoption of all the adaption strategies except for use of manure implying that ease of access to the market increased farmers probability of adopting the different adaption strategies. Proximity to market facilitates farmers' access to information and agricultural inputs such as hybrid crop varieties, fertilizers and pesticides as well as a market for selling agricultural outputs increasing the likelihood of adopting different adaptation strategies. The results are in consonance with findings by Marie et al. (2020) who noted that farmers with access to market were 0.34 times more likely to adopt climate change adaptation strategies than those without. Further, the results corroborate findings by Belay et al. (2017) who found a positive and significant effect of distance to market on farmer input intensity and crop diversification.

Lastly, land size increased the probability of adopting drought resilient crops while reducing the probability of adopting use of fertilizers. The mixed effect of land size on adoption of the different strategies could be because a large farm size allows farmers space to practice crop diversification and also discourage adoption of high cost strategies. The results of the study are in consonance with findings from Žurovec and Vedeld (2019). A positive and significant relationship between land size and farmers' adoption of a combination of several adaptation strategies such as agroforestry, perennial plantation, crop–livestock diversification and improved varieties was also reported by Fadina and Barjolle (2018).

V. CONCLUSION AND RECOMMENDATIONS

The study established that age, gender, farming experience, membership to farmers' organization, education level of the household head, access to extension services and proximity to market had a significant varying influence on farmers' choice of different adaptation strategies. The study therefore recommends that policies, programs and projects by governmental and non-governmental development agencies aimed at helping farmers adapt to climate variability and extreme events should target specific socio-economic characteristics that are relevant to the adaptation strategies in question.

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