Asian Journal of Agricultural Extension, Economics & Sociology

38(5): 29-41, 2020; Article no.AJAEES.57226
ISSN: 2320-7027

Determinants of Smallholder Farmers' Choice of Climate Smart Agriculture Practices to Adapt to Climate Change in Masaba South Sub-County, Kisii, Kenya

Jared O. Nyang'au[1,2*], Jema H. Mohamed[3], Nelson Mango[4], Clifton Makate[1], Alex N. Wangeci[2,5] and Stephen O. Ahenda[2]

[1]*Africa Center of Excellence for Climate Smart Agriculture and Biodiversity Conservation, Haramaya University, P.O. Box 138, Dire Dawa, Ethiopia.*
[2]*Kenya Plant Health Inspectorate Service (KEPHIS), P.O. Box 49592-00100, Nairobi, Kenya.*
[3]*School of Agricultural Economics and Agribusiness Management, College of Agriculture and Environmental Sciences, Haramaya University, P.O. Box 138, Dire Dawa, Ethiopia.*
[4]*International Centre for Tropical Agriculture (CIAT), P.O. Box MP228, Mt. Pleasant, Harare, Zimbabwe.*
[5]*Sydney Institute of Agriculture, University of Sydney, NSW 2006, Australia.*

Authors' contributions

This work was carried out in collaboration among all authors. Author JON conceived and designed the study, conducted field work, visualized the data, analyzed the data and wrote original draft. Authors JHM and NM Conceived and designed the study, supervised the study, interpreted the data, reviewed and edited the final draft. Author CM designed the methodology, designed the models, did data curation, data analysis and he revised and review final draft. Authors ANW and SOA designed the methodology, designed the models, data analysis, data interpretation and wrote first original draft. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2020/v38i530345
Editor(s):
(1) Dr. Roxana Plesa, University of Petrosani, Romania.
Reviewers:
(1) Martin Potgieter, University of Limpopo, South Africa.
(2) Makuachukwu G. Ojide, Alex Ekwueme Federal University, Ndufu-Alike Ikwo, Nigeria.
Complete Peer review History: http://www.sdiarticle4.com/review-history/57226

Original Research Article

Received 20 March 2020
Accepted 26 May 2020
Published 03 June 2020

ABSTRACT

Aims: This study evaluated determinants that influence choice of Climate-Smart Agricultural (CSA) practices among smallholder farmers in Masaba South sub-county, Kisii, Kenya.

*Corresponding author: E-mail: jaredonyango@gmail.com;

Study Design: This study used a multivariate probit model to evaluate determinants that influence farmers' choice of CSA practices.
Place and Duration of Study: Masaba South sub-county, Kisii, Kenya between the second week of April 2019 and the last week of May 2019.
Methodology: Quantitative and qualitative data were collected using a semi-structured questionnaire from 196 households, 3 focused group discussions and 7 key informant interviews. Information such as socio-economic, land ownership, climate change perception, crop production practices and institutional characteristics were collected from the households.
Results: The results showed that crop diversification, change of crop varieties and crop rotation and/or mixed cropping are the dominant adaptation strategies in the study area. Access to credit, farm income, climate change perception and household size have a significant positive influence on adoption of most CSA practices. Small-sized farms, lack of access to extension services, level of education and inaccessibility to weather and climate information were major barriers influencing adoption of CSA practices.
Conclusion: To reduce vulnerability of smallholder farmers to impacts of climate variability and change, the study recommends the need to enhance increased access to extension services and timely dissemination of climate information to farmers in the form they can easily understand and decode.

Keywords: Climate-smart agriculture; determinants; adoption; adaption; climate change.

1. INTRODUCTION

Kenya, just like other sub-Saharan African countries, is vulnerable to adverse impacts of climate change, which negatively impact the economy and the livelihood of citizens. Smallholder farmers are most vulnerable to the impacts of climate change because of their high dependence on rain-fed agriculture, which is compounded with high levels of poverty, as well as low infrastructural and technological development [1]. The Kenyan agricultural sector is vulnerable to variations in rainfall and extreme weather and climatic events. This threatens the country's food security, economy and people's livelihood [2]. The agriculture sector contributes at least 25% directly and 27% indirectly through linkages of agro-based industries to the country's GDP. It accounts for 65% of total exports, provides about 60% of total employment [3].

Adapting to climate change has been applied as a response strategy to the adverse impacts of changes in climate on a global scale in the United Nations Framework Convention on Climate Change (UNFCC) [4]. Adapting to climate change is important to lessen the negative effects of climate variability and change on people's livelihood, while increasing the capacity of taking advantage of opportunities [5]. This involves carrying out adjustments in regard to socio-economic measures, which will lessen the susceptibility of households, communities, nations and different sectors to the variations in the climate system [6].

Farmers need to adapt in order to shore up their resilience towards different types of changes in their local environment. To cope with the changing nature of climate, it requires farmers to change from their traditional farming practices. One of the practices that can cause transformation and re-orient agricultural practices in the face of climate change is Climate-Smart agriculture (CSA) [7]. CSA involves farming practices that simultaneously increase agricultural productivity, increases adaptive capacity of farmers and reduces greenhouse gases while at the same time contributing to achievement of national development goals [7].

Change in crop varieties, diversification coupled with subsistence diversification have been the main adaptation strategies embraced by small-scale farmers in Sub-Saharan Africa [8]. In Kenya, some identified CSA practices adopted by most smallholder farmers to cope to climate variability and change include: venturing into different and new crop varieties, changing of planting dates by either planting early or late, farmers engaging in crop diversification, swapping to livestock farming in place of crop farming, engaging in non-farming activities, controlling the numbers of livestock and application of different management strategies of livestock farming, increasing irrigation, usage of fertilizers and pesticides, increased application of water and soil conservation techniques, mulching and the application of manure [9].

The choice of adaptation option by most small-holder farmers is influenced by financial capabilities and different contextual factors such as demographic and institutional characteristics [8]. Major household determinants for adoption of technologies and practices include gender, education level, age, family size, income and farmers' experience [10]. With old age, large farming experience, high level of education and large size of family was noted to greatly influence adoption of various strategies to increase resilience against climate change [11]. The Masaba South Sub-county is highly populated and prone to climate variability and change [12]. This coupled with land degradation makes the small scale farming systems vulnerable. This study evaluated the factors influencing farmers' choice of CSA practices, with a focus on smallholder farmers. This forms a basis for intervention measures by various stakeholders to enhance adaptation.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Masaba South Sub-County within Kisii County, Kenya. The sub-county is located in the western part of Kenya between latitude 0°30′ and 1°S and longitude 34°38′ and 35°E. The sub-county has 5 administrative wards, Ichuni, Nyamasibi, Masimba, Gesusu and Kiamokama (Fig. 1).

2.2 Sampling Frame

The target households for this study were selected by utilizing a multi-stage random sampling procedure, according to Sedgwick [13]. The sub-county was purposively selected as it is prone to climate variability and change, according to Robinson [14]. Then, three administrative wards (Masimba, Ichuni, and Gesusu) were selected from the sub-county to be representative of the five wards based on their physiographical and natural conditions, location in the sub-county, food security situation, and types of farming system. This was followed by the random selection of 12 sub-locations (4 from Masimba, 3 from Ichuni and 5 from Gesusu) and finally, households were sampled randomly based on probability proportional to size in each ward. Both primary and secondary data were used for this study. Data was collected between the second week of April 2019 and the last week of May 2019. Primary data was collected by the use of pre-tested structured questionnaires entailing, primarily closed-ended and open-ended questions, focused group discussions, and key informant interviews.

2.3 Sample Size

Sample size of the households was determined by formula as proposed by Cochran [15]. Sample size was estimated at 95% confidence level (z), 7% level of precision, with the expected proportion of households who have adopted CSA practices from population of the farmers assumed to be 50%, (p=0.5) and hence q=p - 1=0.5; as follows;

$$\text{Households} = \frac{1.96^2 \times 0.5(0.5)}{0.07^2} = 196$$

The households were distributed in the three administrative wards proportionately based on the population (Table 1). The selected heads of the households, whether male or female was implicitly assumed to be the sole decision-makers in the selection of appropriate CSA practices to adopt.

2.4 Data Analysis

2.4.1 Descriptive data analysis

Descriptive statistics in SPSS version 23 was used to summarize data on the adaptation strategies by smallholder farmers.

2.4.2 Econometric data analysis

In this study, determinants of smallholder farmers' choice of CSA practices were analyzed using MVP model. In modelling of the determinants of a farmer's choice, it is important to take into consideration that, farmers consider a set of possible CSA practices and choose the particular practice bundle that maximizes expected utility [16]. Thus, the adoption decision is inherently multivariate and attempting univariate modeling excludes useful economic information contained in interdependent and simultaneous adoption decisions. Based on this argument, this study adopted multivariate MVP econometric technique to simultaneously model the influence of the set of explanatory variables on major CSA agriculture practices adopted by farmers, while allowing for the potential correlation between

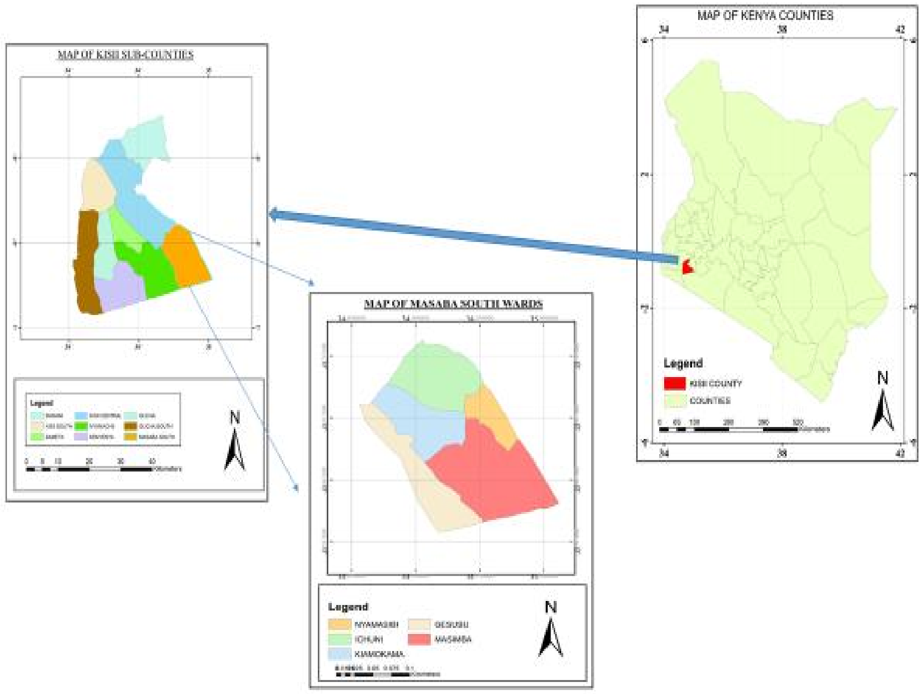

Fig. 1. Location of Masaba South sub county in Kenya

Table 1. Sample size distribution for each ward

Name of ward	No. of sub-locations	Total population	No. of households
Masimba	8	26,013	64
Ichuni	5	27,724	68
Gesusu	9	25,861	64
Total	22	79,598	196

Source: Kenya Bureau of Statistics (KNBS), 2009 census data

unobserved disturbances, as well as the relationship between the adoption of different CSA practices. These determinants were evaluated by use of STATA software. Therefore, the study was based on the premise that there will be complementarity and/or substitutability between different strategies [17].

The mostly adopted CSA practices in the study area were identified and modeled. The adopted CSA practices were modeled following random utility formulation. The model specification was as follows; Considering the i^{th} farm household (i=1, 2…... N), facing a decision problem on whether or not to choose a given CSA practice. Let U_0 represent the benefits to the households who chooses let's say crop diversification, and let U_k represent the benefit to household who choose the K^{th} CSA practice: where K denotes choice; change of crop varieties (Y_1), change of planting time (Y_2), crop rotation and mixed cropping (Y_3), Soil conservation practices (Y_4), use of manure (Y_5) and crop diversification(Y_6). The farmer decides to choose the K^{th} CSA practice if $Y^*_{ik} = U^*_k - U_0 > 0$. The net benefit (Y*ik) that the farmer derives from a climate smart practice is a latent variable determined by observed explanatory variable (Xi) and the error term (ε_i):

$$Y^*_{ik} = X_i \beta_k + \varepsilon_i$$

$$(k = Y_1, Y_2, Y_3, Y_4, Y_5, Y_6) \quad (2.1)$$

Using the indicator function, the unobserved preferences in equation (3.1) translates into the observed binary outcome equation for each choice as follows:

$$Y_{ik} = \begin{cases} 1 \; if \; Y^*_{ik} > 0 \\ 0 \; otherwise \end{cases} \qquad (K = Y_1, Y_2, Y_3, Y_4, Y_5, Y_6) \quad (2.2)$$

Table 2. Independent variable description and hypothesis

Variable	Description	Measurement	Expected sign
Gender	Dummy	1=Male, 0=Female	+/-
Age of respondent	Continuous	Years	+/-
Household size	Continuous	Number	+
Farming experience	Continuous	Years	+/-
Education level	Continuous	Years	+
Farm income	Continuous	Ksh	+/-
Farm size	Continuous	Acreas	+/-
Market distance	Continuous	Kilometres	+
Access to credit	Dummy	1=Yes,0=No	+
Access to extension	Dummy	1=Yes,0=No	+/-
Access to climate and weather information	Dummy	1=Yes,0=No	+
Membership to social group	Dummy	1=Yes,0=No	+
Perceived changes	Dummy	1=Yes,0=No	+

In this model, where the choice of several CSA agriculture practices to adopt to climate change and variability 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 (μ_{y1}, μ_{y2}, μ_{y3}, μ_{y4}, μ_{y5}, μ_{y6}) ~ *MVN* (0,Ω) and the symmetric covariance matrix Ω is given by:-

$$\Omega = \begin{bmatrix} 1 & \rho_{y1y2} & \rho_{y1y3} & \rho_{y1y4} & \rho_{y1y5} & \rho_{y1y6} \\ \rho_{y2y1} & 1 & \rho_{y2y3} & \rho_{y2y4} & \rho_{y2y5} & \rho_{y2y6}, \\ \rho_{y3y1} & \rho_{y3y2} & 1 & \rho_{y3y4} & \rho_{y3y5} & \rho_{y3y6} \\ \rho_{y4y1} & \rho_{y4y2} & \rho_{y4y3} & 1 & \rho_{y4y5} & \rho_{y4y6} \\ \rho_{y5y1} & \rho_{y5y2} & \rho_{y5y3} & \rho_{y5y4} & 1 & \rho_{y5y6} \\ \rho_{y6y1} & \rho_{y6y2} & \rho_{y6y3} & \rho_{y6y4} & \rho_{y6y5} & 1 \end{bmatrix} \quad (2.3)$$

Of particular interest are off-diagonal elements in the covariance matrix, which represent the unobserved correlation between the stochastic components of the different type of CSA practices. This assumption means that equation (2.3) generates a MVP model that jointly represents decision to choice particular CSA practice. This specification with non-zero off-diagonal elements allows for correlation across error terms of several latent equations, which represents unobserved characteristics that affect the choice of alternative CSA practice.

Following the form used by Cappellarri and Jenkins [18], the log-likelihood function associated with a sample outcome is then given by:

$$\ln L = \sum_{i=1}^{N} \omega_i \ln \Phi\,(\mu_i, \Omega) \quad (2.4)$$

Where;

ω_i is an optional weight for observation i, and Φ is the multivariate standard normal distribution with arguments μ_i and Ω, where μ_i can be denoted as:-

$$\mu = (k_{i1}\,\beta_1 X_{i1}, k_{i2}\,\beta_2\,X_{i2}, k_{i3}\beta_3 X_{i3}),$$

While $\Omega_{ik} = 1\ for\ j = k\ and$ (2.5)

$$\Omega_{jk} = \Omega_{kj} = k_{ij}k_{ik}\rho_{jk} for\ j \neq k, k = 1,2,3 \dots .with\ k_{ik} = 2y_{ik} - 1 \quad (2.6)$$

The choice of independent variables which influence dependent variables and the hypotheses was based on empirical studies and literature review. Table 2 indicates the description of the explanatory variables and their hypotheses or expected sign as used in this study.

3. RESULTS AND DISCUSSION

3.1 CSA Practices Adopted by Smallholder Farmers

Through interviews and focused group discussions, farmers identified various CSA practices they have adopted to enhance their resilience. The adoption of these practices was specifically undertaken to increase agricultural productivity and increase resilience to climate variability and change. The commonly adopted practices in the area include crop diversification, change of planting time, crop rotation and/or mixed cropping, use of manure and soil conservation practices (Fig. 2.).

Majority of the smallholder farmers were found to have diversified the kind of crops they grow. They were planting drought resistant crops and other crops not grown in the area before such as sorghum, cowpeas, finger millet, green grams and flowers for export. This was necessitated by the fact that the productivity of the crops which used to be planted in the area were decreasing gradually. The diversification of crops among smallholder farmers has been perceived as one of the most ecologically feasible, cost effective and rational way of reducing uncertainties in agricultural production among small scale farmers [19]. These findings on diversification were consistent with those of Kichamu et al. [20] in Matungulu Sub-County, Eastern Kenya and Wamalwa et al. [21] in Kitutu Chache North, Kitutu Chache South and Nyaribari Chache Sub-counties, Kisii county, Kenya, who identified crop diversification as a major adopted strategy to cope with changing climate.

The proportionate high use of manure by 68.9% of the respondents was attributed to the fact that the cost of fertilizers was relatively high, costing close to a dollar and their continuous use has not proven to increase yield. In this study, 79.1% of farmers changed the timing of their farming activities with an aim of addressing the shifting spells of growing plants to related changes in temperature and soil moisture content The perceived changes in the onset of the rainfall and its distribution informed the change of the planting time. Most of the farmers shifted to planting crops after the onset of rainfall when they were sure there was enough moisture in the soil to provide suitable conditions for growth. In the Key informant interviews and focused group discussions, it was noted that farmers in the Sub-county used to plant between the months of December to February for the first season before the onset of long rainfall season. With the late onset, they have shifted planting between March to May. In the short rainfall season, in which they used to plant in July-August, they have shifted to planting as from September when the rainfall onsets. These findings were consistent with those of Kahsay et al. [22], who found that 83.60 % and 86% farmers in Hawzen and Irob respectively in Northern Ethiopia adopted change of planting time as an adaptation strategy to overcome the effects of climate change.

It was found that 77.6% of the farmers practiced either crop rotation and/or mixed cropping with an intention of increasing productivity. With mixed cropping, farmers had the potential to curtail complete crop failure as the crops are affected by climate differently. From focused group discussions, farmers noted that mixed cropping allows them to grow more than one crop at a time and this cushions them in case of failure of one crop. The strategy was preferred for adaptation as it utilized the decreased land sizes due to sub-division attributed to overpopulation in the area [12], effectively for optimal produce. The major food crop grown under mixed cropping were mainly identified as maize and beans while crop rotation was mostly done with either maize, beans and finger millet. Mixed cropping has an advantage of allowing greater production from the same land, while not causing additional degradation to the soil, as the crops will require different nutrients and can be mutually beneficial to each other [23]. Those farmers who adopted soil conservation practices did so to retain water for prolonged period to support growth of crops and control soil erosion. The collected water can be used to irrigate crops during dry spells to increase yield stability or for planting off-season, to increase household income. This practice was adopted by relatively few people as it requires investment costs and knowledge which restrict widespread up-take by smallholder farmers [24].

3.2 Determinants of Smallholder Farmers' Choice of CSA Practices to Adapt to Climate Change

The MVP likelihood ratio test, Wald chi-square (72) = 176.83, Prob > chi2=0.000, for independence between the disturbances is strongly rejected, implying correlated binary responses between different CSA practices. This supports the use of MVP. The model was used to analyze the determinants of households' decision on adoption of the six CSA practices mostly adopted by smallholder farmers in the study area. The practices evaluated include change of crop varieties, crop rotation and/or mixed cropping, change of planting time, soil conservation practices, use of manure and crop diversification (Table 3).

They were modelled to evaluate the influence of various explanatory variables on the choices of farmers on various CSA practices. The correlation coefficients of the error terms in MVP had positive as well as negative signs, indicating that there was interdependency between different CSA adaptation strategies chosen by households. The signs of correlation coefficients indicate the complementarity of different adaptation strategies. The base category in the model were the non-adapters in each practice. Multicollinearity test confirmed a strong relationship between age and farming experience. Since age of a farmer is proxy of a farming experience, farming experience was removed from the model.

The results on correlation coefficients of the error terms indicate that there are complementarities between different CSA practices adopted by farmers. The results support the assumption of interdependence between different adaptation options which may be due to complementarity in the different adaptation options and also from omitted household-specific and other factors that affect uptake of all the CSA practices under consideration (Table 4). It was found that both socio-economic, farm characteristics and institutional factors significantly influenced the adoption of CSA practices either positively or negatively to enhance farmers' resilience and increase agricultural productivity. Therefore, strategic interventions initiated by various levels of government, non-governmental organizations and other development agencies to tackle climate variability and change would benefit from detail analysis of the variables under each category as summarized in Table 3.

Results from the model (Table 4) indicates that being a male positively influenced adoption of the use of manure as an adaptation strategy against climate change at 10% significance level. As hypothesized, gender of the respondent can either positively or negatively influence adoption of CSA practices. Being a male increases likelihood of use of manure as an adaptation strategy. These findings support those of Mutunga et al. [10], that showed that male headed households are more likely to adopt technologies to overcome negative impacts of climate change as they are likely to have better access to extension services, climate change information and can take risks than female headed households. Males are also more likely to take risks to adapt than their female counterparts [25].

Large households are more likely to have adequate labour for the adoption of CSA practices. Results reveal that household size had a positive significant influence in the adoption of the use of manure strategy at 5% significance level, soil conservation and crop rotation/mixed cropping strategies at 10% significance level. Large household size increases the likelihood of adaptation as it is associated with labor-intensive agricultural practices [26]. Some of the CSA practices such as soil conservation and mixed cropping are labour intensive. Handling of manure from the sites and application is tiresome and requires more labour. Thus, large household size has a significant positive influence in the adoption of these practices. These findings support those of Ochieng et al. [27] and Akumbole et al. [28] who found that large

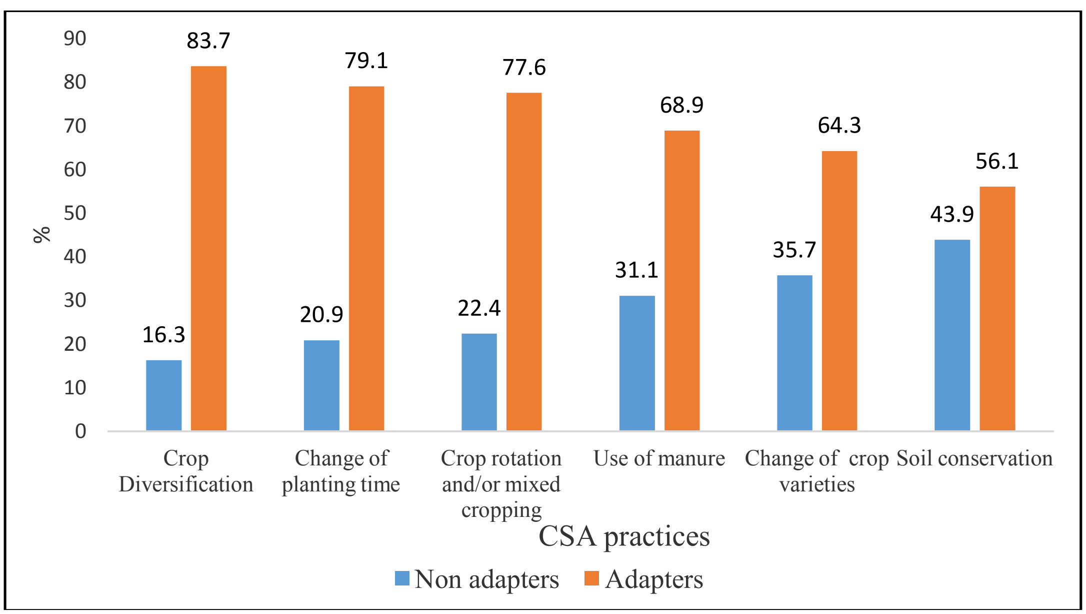

Fig. 2. CSA practices adopted by smallholder farmers

Table 3. Descriptive statistics of variables

Variable	Mean	Std deviation	Minimum	Maximum
Gender	0.408	0.493	0	1
Age of respondent	42.388	13.839	19	78
Household size	4.036	2.054	0	1
Education level	10.332	3.675	0	16
Farm income	6271.684	7599.111	100	45000
Farm size	1.870	1.820	0.1	15
Market distance	2.823	2.303	0	15
Access to credit	0.413	0.494	0	1
Access to extension	0.173	0.380	0	1
Access to climate and weather information	0.740	0.440	0	1
Membership to social group	0.561	0.508	0	1
Perceived changes	0.878	0.329	0	1
Crop diversification	0.837	0.371	0	1
Change of planting time	0.791	0.408	0	1
Crop rotation and/or mixed cropping	0.776	0.418	0	1
Use of Manure	0.689	0.464	0	1
Change of crop varieties	0.643	0.480	0	1
Soil conservation	0.561	0.498	0	1

household size influenced adoption of planting of trees and improved maize technology. Despite household size being found to positively influence adoption of the three practices, it negatively influenced adoption of change of crop varieties. This contradicts the initial hypothesis of large household being hypothesized to positively influence adaptation. This can be attributed to that fact that, as the size of the household increases, they divert their labour to other off-farm activities to get an extra income to reduce consumption pressure exerted by the large size. This is consistent with finding of Mihiretu et al. [29] who found that large household size negatively influenced the adaptation of crop diversification.

High level of education is hypothesized to significantly influence adoption of CSA practices to increase resilience against climate variability and change [10]. Our results revealed that increase in the number of years spent in school had a positive significant influence on the choice of the use of manure as the adaptation strategy at 10% significant level. Using manure as adaptation strategy to enhance resilient and increase agricultural productivity requires an understanding of the benefits that can be accrued from manure and proper management skills. This is because educated farmers are expected to adopt new technologies based on their awareness of the potential benefits from the proposed climate change adaptation measures [30]. A higher level of education of a farmer is likely to be associated with knowledge and information on climate variability and change, improved technologies, and higher productivity, therefore appropriate adaptation strategy might be selected. Increase in the number of years spent in school however reduced the likelihood of adopting crop diversification at 5% significance level. Less educated farmers were more likely to diversify their crops to enhance their resilience because they consider growing of different crops as a way of spreading their risks. To enhance adoption of other practices, there is need to promote education through farm management trainings and farmer schools. This is consistence with findings of Addisu et al. [31] and Mutunga et al. [10] who reported on the positive influence of the education level in the adoption of practices to enhance resilience against climate change.

Farm income positively and significantly ($p< 0.05$) influenced adoption of soil conservation practices and use of manure at 5% significance level. Households generating better income and having adequate assets are better placed to adopt new farming practices [32]. Soil conservation practices and proper use of manure require capital investments. The wealthier farmers are likely to adopt these practices than the less endowed in the community. These findings are consistent with those of Belay et al. [33] and Debalke, [34] who found that income has a positive relation with soil conservation measures, changes in planting date and use of crop diversification. The findings also supports those of Akumbole et al. [28] who found that large farm income positively enhances adaptation of improved maize technology.

Table 4. Multivariate probit results for determinants of adoption of CSA practices

Variables	Use of manure		Change of planting time		Crop rotation &/or mixed cropping		Change of crop varieties		Crop diversification		Soil Conservation practices	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Gender	0.584*	0.256	0.044	0.236	0.352	0.240	-0.167	0.208	-0.051	0.234	0.226	0.220
Age	-0.011	0.009	0.002	0.009	-0.010	0.009	-0.008	0.008	0.000	0.009	-0.014	0.009
Household size	0.189**	0.060	-0.060	0.054	0.118*	0.056	-0.123*	0.051	-0.002	0.060	0.117*	0.055
Education level	0.080*	0.031	0.002	0.031	0.016	0.030	-0.014	0.029	-0.096*	0.043	0.031	0.029
Farm income	0.000**	0.000	0.000	0.000	0.000	0.000	-0.000	0.000	-0.000	0.000	0.000**	0.000
Farm size	-0.027	0.076	-0.022	0.063	0.022	0.070	0.088	0.059	0.003	0.063	0.124	0.078
Market distance	-0.014	0.048	0.137	0.070	-0.005	0.043	0.094	0.057	0.028	0.050	-0.027	0.050
Access to credit	0.837**	0.274	1.012***	0.273	0.745**	0.255	-0.645**	0.220	0.361	0.244	1.292***	0.254
Extension services	-0.741*	0.296	-0.181	0.289	-0.567*	0.279	0.578	0.305	-0.396	0.287	-0.766**	0.295
Weather& climate information	-0.397	0.321	-0.020	0.264	0.224	0.265	0.709**	0.233	-0.128	0.278	-0.425	0.273
Social group membership	-0.564*	0.236	-0.063	0.220	0.170	0.211	0.522*	0.210	0.254	0.229	-0.315	0.219
Climate change perception	1.475***	0.376	-0.124	0.365	0.571	0.313	-0.241	0.313	0.087	0.328	0.969**	0.348
Constant	-1.876*	0.760	0.461	0.708	-0.515	0.673	0.718	0.664	1.851*	0.848	-1.334	0.718
Number of observations	196											
Number of simulations	5											
Log likelihood	-503.0538											
Wald χ^2 (78)	176.83											
Prob > chi2	0.0000											

*Note: *** significant at 1%, **significant at 5% and * significant at 10%. 95 % confidence intervals in parenthese*

Accessibility of credit and its utilization by farmers is an important factor to narrow the financial gap of the farmers. This can help farmers purchase the required farm inputs and technologies that are useful adaptation to environmental changes and also diversify their income activities from farming. The access to credit significantly influenced the adoption of soil conservation practices, crop rotation and mixed cropping, and use of manure at 5% significance level and change of planting time at 1% significance level. With the financial resource at farmers' disposal, they are able to change their management practices in response to climate change. Access to capital help farmers purchase necessary agro-inputs required such as fertilizers and certified seeds for mixed cropping, purchase equipment to aid in manure application and other inputs they may need to change their practices to suit the prevailing climatic conditions. These finding are in line with Ochieng et al. [27] and Mutunga et al. [10] who reported that farmers who had access to credit facilities were more likely to adopt soil and water conservation practices to enhance their resilience to climate change. The access to credit reduced the likelihood of adoption of change of crop varieties. This can be attributed to the fact that farmers who had access to credit opted to adopt other practices which they thought would improve their productivity. Those who did have access were more likely to change crop varieties by either use of retained seeds from previous harvest or free trial samples from seed merchants.

Access to extension services entails dissemination of useful and practical information related to agriculture, including improved farm inputs, farming techniques and skills to farmers or rural communities with the objective of improving their farm production and income [35]. Respondents who have access to extension services are hypothesized to be more likely to adjust farming practices to respond to changes in climate as they are likely to get relevant information [36]. The results in Table 4 indicates that it is significantly and negatively related to the likelihood of use of manure, adoption of crop rotation and mixed cropping practice; and soil conservation practices in the study area. This might be attributed to the fact that farmers get poor information on CSA practices and/or the extension services providers are not well conversant with some of the CSA practices. Additionally, the less frequent contact between the service providers and farmers might result in farmers' loss of confidence in the practices they promote within their areas.

Access to weather and climate information is an important variable that affects adaptation options. Results indicate that access to this information significantly influences the adoption of change of crop variety at 5% significance level. The weather forecast information can enable them plan on whether to plant short maturity crops or long maturity crops. Acquisition of information about weather and climate on additional to the available information about climate change to farmers, increases the rate of adaptation. The presence of well-functioning weather stations and proper processing of weather data and dissemination of weather forecasts as well as acceptance of the information by users is assumed to influence adaptation efforts to climate change [37]. The availability of weather forecast information to farmers enables them to make informed decisions on which crops and crop varieties to plant [9]. The findings are consistent with Maguza-Tembo et al. [32], Belay et al. [33] and Debalke [34] who found that farmers who had access to weather information adopted change of varieties strategy by either growing early maturity or drought resistant variety among other practices. It is also consistence with the findings of Mulwa et al. [38] and Stefanovic et al. [39] in parts of Kenya who found that accessibility to extension services and weather and climate information was positively correlated to the change of crop varieties as an adaptation strategy.

Farmers perception on climate change through the declining trend and poor distribution of rainfall as well as incidences of increasing temperatures can motivate farmers to adapt. Perception of climate change significantly influenced the adoption of soil conservation and use of manure strategy at 5% and 1% significance level respectively. This supports the findings of Ochieng et al. [27] who reported that those farmers who perceived decline in amount of rainfall received and increase in temperature, were more likely to adopt soil conservation practices. Additionally, it supports findings of Maguza-Tembo et al. [32] that found that farmers' who were able to foresee drought were more likely to adopt soil and conservation practices, crop diversification and water harvesting. Raising the awareness of climatic changes among smallholder farmers would have a significant impact on adaptation. Collaboration of various stakeholders to raise awareness through various communication pathways, accompanied with various knowledge of farming practices, can influence farmers' response to through adoption of CSA practices.

Membership to a social group is hypothesized to positively influence adoption. In social gatherings, farmers get information from other members about climate change which might influence adaptation. It was found that membership to a social group significantly influenced choice of change of crop variety as an adaptation strategy at 10% significance level. During meetings in the groups, farmers often share information of the new crop varieties in the market and those who might not be aware are likely to receive the information and adapt. These findings contradict those of Mulwa et al. [38] who reported that membership to a farmer group negatively influenced adoption of the drought tolerant varieties.

Small sized farms, lack of access to extension services and inaccessibility to weather and climate information were identified as the major barriers affecting adoption of CSA practices. Therefore, there is need to enhance capacity building of extension services and ensure availability of weather and climate information to farmers in the form they can easily understand. The small sized farms limit adoption of some practices which require capital intensive investment and whose benefits are long-term.

4. CONCLUSION

This study examined the determinants of smallholder farmers in the study area to adopt various CSA practices. This was intentioned so as to understand significant determinants of farmers' choice of various CSA practices to aid in designing impactful adaptation interventions in the locality. A MVP model was used to assess how various independent variables influence adoption of crop diversification, change of planting time, crop rotation and/or mixed cropping, use of manure, change of crop varieties and soil conservation as adaptation strategies. The findings demonstrate that various independent variables influence adoption of CSA practices differently. For instance, access to credit, farm income, climate change perception and household size showed a significant positive influence in adoption of most of CSA practices while small farm sizes, lack of access to extension services, level of education and inaccessibility to weather and climate information were identified as the major barriers affecting adoption of CSA practices. These findings are limited to one sub-county of Kisii county as the CSA practices are context specific, hence need to study other sub-counties. To reduce vulnerability to impacts of climate variability and change, the government and other stakeholders should enhance education and extension services to smallholder farmers in the study area as well as avail timely and easily comprehensible weather and climate information. This study forms a basis for the respective county authorities in the ministry of agriculture to develop intervention measures that help farmers within the locality build resilience and adapt to effects of climate change.

CONSENT

All authors declare that informed consent was obtained from the sampled household participants for publication of this case article. Approval was obtained from National Commission for Science, Technology, and Innovation (NACOSTI), Kenya, and a research permit issued under permit number, NACOSTI/P/19/19905/27337 to facilitate data collection from smallholder farmers. Additionally, in collecting data from respondents, their consent was sought first before conducting an interview.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the financial assistance received from World Bank through the Africa Centre of Excellence for Climate Smart Agriculture and Biodiversity Conservation as part of first author's M.Sc. Program. The Centre is hosted at Haramaya University, Ethiopia. We appreciate all the enumerators for the good work in helping in data collection and the smallholder farmers in the study area for their patience and time in responding to our questions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Adimassu Z, Kessler A. Factors affecting farmers' coping and adaptation strategies to perceived trends of declining rainfall and crop productivity in the central Rift valley of

Ethiopia. Environ Syst Res. 2016;5:1–13.
2. GoK (Government of Kenya). Kenya Climate Smart Agriculture Strategy; 2017-2026; 2017.
3. UNEP. Green Economy Sector study on agriculture in Kenya. 2015;34.
4. IPCC. An IPCC Special Report on the impacts of global warming of 1.5°C. Intergov Panel Clim Chang; 2018.
5. IPCC. Special Report on Climate Change and Land. Ipcc; 2019;
6. Füssel HM. Vulnerability: A generally applicable conceptual framework for climate change research. Glob Environ Chang; 2007.
7. FAO. Climate-Smart Agriculture Source Book. Food and Agriculture Organization of the United Nations. Sourcebook on Climate-Smart Agriculture, Forestry and Fisheries; 2013.
8. Gbetibouo GA. Understanding farmers' perceptions and adaptations to climate change and variability: The case of the Limpopo basin, South Africa. IFPRI Discussion Paper 00849; 2009.
9. Mutunga E, Ndungu C, Muendo P. Smallholder farmers perceptions and adaptations to climate change and variability in kitui County, Kenya. J Earth Sci Clim Change. 2017;8(3):1–7.
10. Mutunga E, Ndungu C, Muendo Patricia. Factors influencing smallholder farmers' adaptation to climate variability in Kitui County, Kenya. Int J Environ Sci Nat Resour. 2018;8(5):155–61.
11. Kimani NC, Bhardwaj SK. Assessment of people's perceptions and adaptations to climate change and variability in mid-hills of Himachal Pradesh, India. Int J Curr Microbiol Appl Sci. 2015;4(8):47–60.
12. Kisii County Government. The First County Integrated Development Plan; 2013-2017; 2013.
13. Sedgwick P. Multistage sampling. BMJ. 2015;351.
Available:http://dx.doi.org/doi:10.1136/bmj.h4155
14. Robinson RS. Purposive Sampling. In: Encyclopedia of Quality of Life and Well-Being Research; 2014.
15. Cochran WG. Stratified random sampling, further aspects of stratified sampling. Sampling techniques; 1977.
16. Mwungu CM, Mwongera C, Shikuku KM, Acosta M, Läderach P. Determinants of adoption of climate-smart agriculture technologies at farm plot level: an assessment from southern tanzania. in: handbook of climate change resilience; 2018.
17. Belderbos R, Carree M, Diederen B, Lokshin B, Veugelers R. Heterogeneity in R&D cooperation strategies. Int J Ind Organ; 2004.
18. Cappellari L, Jenkins SP. Multivariate probit regression using simulated maximum likelihood. Stata J Promot Commun Stat Stata; 2003.
19. Makate C, Wang R, Makate M, Mango N. Crop diversification and livelihoods of smallholder farmers in Zimbabwe: Adaptive management for environmental change. Springerplus; 2016.
20. Kichamu EA, Ziro JS, Palaniappan G, Ross H. Climate change perceptions and adaptations of smallholder farmers in Eastern Kenya. Environ Dev Sustain. 2018;20(6):2663–80.
21. Wamalwa IW, Mburu BK, Mang'uriu DG. Perception of climate change effects and its influence on uptake of climate smart practices among small scale farmers of Kisii County, Kenya. Int J Inf Res Rev. 2016;3(5):2409-2417.
22. Kahsay HT, Guta DD, Birhanu BS, Gidey TG, Routray JK. Farmers' perceptions of climate change trends and adaptation strategies in semiarid highlands of Eastern Tigray, Northern Ethiopia. Adv Meteorol; 2019.
23. Katharine V, Cull T, Chanika D, Hamazakaza P, Joubert A, Macome E, et al. Farmers' responses to climate variability and change in southern Africa - is it coping or adaptation? Clim Dev. 2013; 5(3):194–205.
24. Fox P, Rockström J, Barron J. Risk analysis and economic viability of water harvesting for supplemental irrigation in semi-arid Burkina Faso and Kenya. Agric Syst; 2005.
25. Urgessa G. Spatial and temporal uncertainty of rainfall in arid and semi-Arid areas of Ethiopia. Sci Technol Arts Res J; 2014.
26. Marenya PP, Barrett CB. Household-level determinants of adoption of improved natural resources management practices among smallholder farmers in western Kenya. Food Policy. 2007;32: 515–36.
27. Ochieng J, Kirimi L, Makau J. Adapting to climate variability and change in rural Kenya: farmer perceptions, strategies and

climate trends. Nat Resour Forum. 2017; 41:195–208.
28. Akumbole JA, Zakaria H, Adam H. Determinants of adoption of improved maize technology among smallholder maize farmers in the Bawku West District of the Upper East Region of Ghana. Agric Ext J. 2018;2(3):165–75.
29. Mihiretu A, Okoyo EN, Lemma T. Determinants of adaptation choices to climate change in agro-pastoral dry lands of Northeastern Amhara, Ethiopia. Cogent Environ Sci; 2019.
30. Nhemachena C, Hassan R. Micro-Level Analysis of Farmers Adaption to climate change in Southern Africa. booksgooglecom; 2007.
31. Addisu S, Fissha G, Gediff B, Asmelash Y. Perception and adaptation models of climate change by the rural people of lake Tana Sub-Basin, Ethiopia. Environ Syst Res; 2016.
32. Maguza-Tembo F, Edriss A-K, Mangisoni J. Determinants of climate smart agriculture technology adoption in the drought prone districts of Malawi using a multivariate probit analysis. Asian J Agric Extension, Econ Sociol; 2017.
33. Belay A, Recha JW, Woldeamanuel T, Morton JF. Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. Agric Food Secur. 2017;6(1).
34. Debalke NM. Determinants of farmers' preference for adaptation strategies to climate change: Evidence from north shoa zone of Amhara region Ethiopia. Munich Pers RePEc Arch; 2013.
35. Syngenta. Agricultural Extension, Improving the livelihood of smallholder farmers; 2014.
36. Yesuf M, di Falco S, Deressa T, Ringler C, Kohlin G. The impact of climate change and adaptation on food production in low-income countries: Evidence from the Nile Basin, Ethiopia. IFPRI Discussion Paper. Washington, D.C.. 2008;(24). Available:http://www.ifpri.org/publication/impact-climate-change-and-adaptation-food-production-low-income-countries
37. Shilenje ZW, Ogwang BA. The Role of Kenya Meteorological Service in Weather Early Warning in Kenya. Int J Atmos Sci; 2015.
38. Mulwa C, Marenya P, Rahut DB, Kassie M. Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics. Clim Risk Manag; 2017.
39. Stefanovic JO, Yang H, Zhou Y, Kamali B, Ogalleh SA. Adaption to climate change: A case study of two agricultural systems from Kenya. Clim Dev; 2017.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/57226