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Factors influencing adoption of climate-smart practices by smallholder avocado farmers for integrated watershed conservation

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Abstract

This study investigates the adoption of climate-smart agricultural practices among avocado growers in the Upper Mara watershed, Kenya. Climate change affects agriculture positively and negatively, and climate-smart agriculture is a strategy that aims to increase productivity, resilience, and reduce greenhouse gas emissions. This research used a participatory action research design with a cross-sectional approach, and a three-stage purposive sampling procedure to collect data from avocado growers. The study employed descriptive statistics, multinomial logit (MNL) models, regression analysis, and chi-square tests to identify the factors that influence farmers' adoption of climate-smart practices. The results show that farmers' education level, access to extension services and credit, information on climate, planting techniques, agroecological settings, and avocado planting duration significantly influence their adoption of climate-smart practices. Grass strip cropping, mulching, intercropping, crop rotation, and agroforestry were found to be the most effective climate-smart and conservation practices in the Upper Mara watershed. The study recommends providing climate-smart training and policy support to increase the spread of these practices. The main barriers to adoption are a lack of information on adaptation methods and financial constraints. This research can help guide policies and programs aimed at promoting sustainable agricultural practices in the context of climate change.

Keywords: Adoption; Avocado; Climate-smart practice; Climate Resilience; Upper Mara; Watershed Conservation

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1. Introduction

Land degradation in the Upper Mara River Basin has taken several forms, threatening the ecosystem's forests, soils, water, biodiversity, and economic and social services (Matano et al., 2015). Land resources are rapidly deteriorating due to deforestation, soil erosion, agricultural expansion, and overgrazing. As a result, the Mara wetland has experienced increased droughts and flooding, resulting in lower crop yields and lower water quality for farm use (Alavaisha et al., 2019). Agricultural development plans and expansions are still being developed, resulting in land subdivisions into smaller parcels (Ibid). According to the Kenya Bureau of Statistics (KNBS) (2019), the progressive land subdivision has resulted in fewer economic units in a fragile landscape, with households owning an average of 1.5 ha of agricultural land. This has made it much more difficult for smallholder farmers to sustainably maintain soils and reduce the rate of land degradation (De Lollo et al., 2018).

This call for stakeholders in the Upper Mara watershed to work together to manage land degradation. As a result, the community-based intervention appears to be a better intervention. Community-based interventions are labour-intensive, site-specific, and necessitate significant capacity development (Neufeldt et al., 2013). Many innovation systems researchers believe that scaling up participatory community-driven approaches to sustainable agriculture can result in equitable agricultural transformation (Porter et al., 2014; Nagothu et al., 2016). Conservation agriculture, agroecology, ecosystem-based management, small-scale irrigation, agroforestry, soil/water conservation, and grazing land management are examples of low-cost sustainable agriculture practices that have been used for decades (Sykes et al., 2020).

The Mau Mara Serengeti Initiative introduced avocado, a fruit tree, to Mara River Basin communities to shield farmers from the effects of Maize Lethal Necrotic Disease (MLND). MLND significantly reduced maize production and jeopardized the community's food security (Morgan et al., 2020). Avocado has been integrated into farming systems in the Upper Mara watershed as a climate-smart practice to increase the area of the avocado canopy. The need to adopt climate-smart practices in response to land degradation challenges in the Upper Mara Basin in Bomet County has ensured stable conditions and improved food supply. There are also mitigation benefits from diversity in cropping systems on the effects of land degradation when using climate-Smart practices. Climate-smart processes should be community-driven, participatory, and inclusive (Aggarwal et al., 2018).

The community-based climate-smart practice is an approach designed to absorb the methods, technological capabilities, and localized capabilities involved in addressing climate change in agriculture (Lipper et al., 2014). Community-based climate-smart practices are the result of participatory action research and evaluation in which researchers and farmers collaborate to diagnose a problem, generate evidence, and identify innovative interventions (e.g., practices or services) and institutional interventions (Aggarwal et al., 2018). Built on the concept of climate-smart agriculture (CSA), it aims to collect local evidence of what constitutes climate-smart agriculture (CSA), the best option for producing empirical evidence for policymakers, agricultural development practitioners, and local and global investors (Ibid).

All relevant stakeholders in the Upper Mara watershed were able to participate in landscape planning, conservation, implementation, and monitoring of climate-smart practices using the climate-smart agroecosystem approach (Bezner Kerr et al., 2018; Ridolfi, et al., 2018). Integrated land management initiatives involving farmers, farmer cooperatives, water resource users' associations (WRUAs), and community forest associations (CFAs) and emphasizing climate-smart practices are critical to achieving these desired outcomes

(Fitzgibbon, 2012; Crossland et al., 2018). Farmers are encouraged to develop community-based climatic smart solutions and adapt to projected climate change and risks by, among other things, establishing links with climate experts and making informed decisions on appropriate interventions (Campbell et al., 2016).

The integration of avocados into the farming systems for watershed conservation is considered an innovation by smallholder farmers. This study was conceptualised based on the innovation system approach (Lundvall et al. 2009). Innovation systems thinking has been developed in a way that includes not just technological innovation but also innovation that is institutional, organizational, and social in nature. The innovation process is based on participatory research, in which multidisciplinary stakeholders collaborate to find new solutions to farmers' needs (Klerkx et al., 2012). Smallholder farmers who strive for innovation drive innovation, and all farmers, scientists, technicians, and other stakeholders in the Upper Mara watershed are innovators in mitigating climate change shocks.

This article sought to assess how smallholder farmers' farms promoted community-based climate-smart practices and what the benefits of this system were at the farm level. What were the motivators and major constraints of climate-smart practices? This paper is organized into four sections. Following the introduction in section one, section two presents the literature. The following section describes the article's methodology. The third section contains the results and discussions of the findings, and the final section contains the articles' conclusions.

2. Methodology

2.1. Location of the study

The research will be conducted in the Upper Mara watershed in Kenya's Bomet County (Fig.1), which is located between the coordinates of $0^{0}45$'S and 10S latitude and 35^{0} and $35^{0}15$' E longitude, at an elevation of 1900-2970M above sea level (Jaetzold et al., 2009).

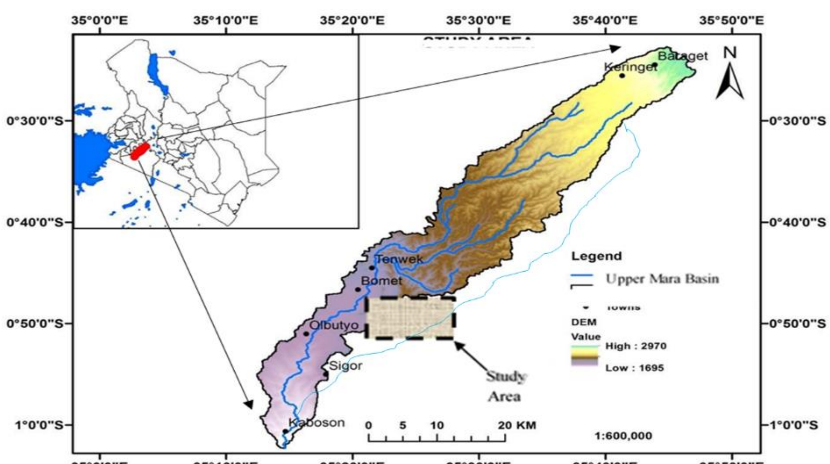

Figure 1. Map of Upper Mara Watershed (Source: Author).

The Administrative location of the Upper Mara watershed in Bomet County falls within three Lower Highland (LH) agro-ecological zones (AEZ) as follows: Lower highland zone one (LH1): This zone is in the upper parts to the North covering Merigi and Chemaner Wards, classified as the Tea/ dairy zone (LH1). Lower highland zone two (LH2): This is in the middle part of the basin, which covers Kembu Ward and is classified as a wheat/ maize/ pyrethrum zone. Lower highland zone three (LH3): Occurs in the lower part of the basin and covers Longisa and Kipreres Wards in Bomet East and lower parts of Mulot division/ Ilmotiok Ward is classified as a wheat/maize/barley zone (GoK, 2019).

2.2. Research design

The study specifically applied a cross-sectional design based on which the sample was selected, and the data collected. The study employed a quantitative approach to evaluate the community-based climate-smart practices in the farming system and the factors influencing their choice by avocado smallholder farming households in the three agroecological zones (Upper, Mid and Lower zones).

2.3. Target population

The study targeted farm- households in Bomet East and Narok West Sub-Counties living within 15 Kilometres of Trans Mara Block in Mau Forest Complex and using the forest directly and indirectly (MOALF and I, 2019). To obtain an accessible population for the study, the sampling formula, $S = (z^2 * p * q) / e^2$, was used in accordance with Cochran (1977), over ten thousand on large population people sampling size procedures. Where Z = Z value 1.96, p = percentage of population picking a choice (5 percent = 0.05), e = margin of error (0.05), q = 1-p, (1-0.5) = 0.5. Thus, the accessible population consists of 1097 farm households distributed across four wards in Upper Mara Basin, Bomet County: Kembu, Longisa, Kapreres, and Ilmotiok, all of which are comprised of small-scale farmers (SNV, 2019).

2.4. Sampling procedure and sample size

A multi-stage purposive sampling procedure was to select the respondents in the study area (Lawal and Jibowo, 2004). In stage one, the Upper Mara watershed that comprised the Bomet East and Narok West Sub-Counties was purposive because degradation remains a major challenge (Wekesa et al., 2018). Four wards in Bomet East and Narok west Sub-counties were chosen for stage two due to avocado farming, which is practised by CFAs and WRUAs in these wards (Wekesa et al., 2018). In the final stage, respondents were obtained using the simple random sampling (SRS) formula (Equation 1).

$$n = \frac{N}{1+N(e)^2} \qquad (1)$$

Using this formula, the total number of farm households in this study = 1097 (Table 1), and the error, e, is 95 percent confidence level = 0.05; thus, 293 households were sampled for the study. Where n represents the sample size, N represents the population size, and e represents the precision. (5 percent SE for this study).

2.5. Data collection

Data was collected by completing a household survey questionnaire for avocado growers to collect information on demographic, socioeconomic, and situational factors, the type of climate-smart practices used, and the extent of degradation on their farms. Gender, age, formal education level, marital status, number of years the farmer has been growing avocado, average land size, and existing avocado planting techniques were among the key variables of interest.

In addition, an observation guide form was used to record data on farming practices on the farms, including conservation practices, soil protection practices, farming system management practices, climate-resilient practices, constraints to conservation practices, and evidence of capacity building to the farmers. An observation guide form was filled out to collect data: conservation practices e.g., grass strips and mulches, conditions of the home garden, cover cropping, mixed cropping, green manuring and condition and types of fruit orchards, condition of tree and fruit cover on the farm, common tree and fruit nurseries on the farm, avocado plantings in the farms, crop diversity, soil and /water conservation practice, diversification of agricultural production, agroforestry techniques and practices common on the farm. The guide was used to complement baseline survey data and triangulate findings (Gayen et al., 2019). The principal component analysis (PCA) was used to simplify data to key variables shown in Table 1.

2.5.1. Validity

Mixed methods were used for data collection, including a household survey and a researchers' observation guide. Confirmatory factor analysis was used to validate the data (Denis, 2018). Confirmatory factor analysis (CFA) is a statistical method used to confirm or validate the internal structure of survey data obtained from reliability and principal factor analysis (PCA) (Prasad and Muralidhar, 2021). Because the model produced by PCA acted as the construct's concept, SPSS version 26 was the chosen software package for conducting confirmatory factor analysis (Prasad and Muralidhar, 2021). PCA is used to simplify data, whereas confirmatory factor analysis is used to evaluate the "sense" and "structure" of piloted surveys (Prasad and Muralidhar, 2021).

2.5.2. Reliability

Pilot-testing of the questionnaire was conducted with a sample size of 10% of avocado farmers, as recommended by Shaheen and Pradhan (2019). Cronbach's Alpha Coefficient, which is used to test capacities, knowledge, attitudes, and behaviour, was used to verify the internal consistency of the household questionnaire (Schrepp, 2020). The reliability coefficient was calculated to be 0.86. Cronbach's alpha coefficient levels of at least 0.70 are recommended (Schrepp, 2020). Hence this study’s data collection instruments were reliable. Cross-referencing data from various methods also helped the general reliability and credibility of the study process.

2.6. Data analysis

Data were analyzed using the Statistical Package for Social Scientists (SPSS) version 26. Descriptive statistics were used to characterize respondents (Sedebo et al., 2022). In each agroecological zone, the presence of community-based climate-smart practices on smallholder farmer farms was evaluated. Unordered variables such as age, gender, education level, planting techniques, farm size, and climate-smart practices on farms were analyzed using the multinomial logit (MNL) model (Quattara et al., 2022). This test was chosen because it allows for analysis of unordered variables and comparisons of the averages of multiple variables. Chi-square analysis was used to test the relationship between conservation practices and agroecological zones (Gessese and Dassa, 2022). Having followed the data-gathering procedure, the data was imported into a spreadsheet for coding so that it could be analyzed using the Statistical Package for Social Sciences (SPSS). Table 1 displays the model's variables.

Table 1. Variables and measurement levels used in the multinomial logistic regression model

Variable Name ***Dependent Variable***	**Type of Measurement**	**Prior Expectations**
Community-based climate-smart practices		
Independent variables		
Gender of HH	Dummy	+
Age of HH	Actual number in years	+
Education level of HH	Years spent in school	+/−
Farm size	Continuous	+/−
Planting duration	Continuous	+
Training	Dummy	+
Linkage to cooperative	Dummy	+
Access to extension services	Dummy	+/−
Avocado planting techniques	Dummy	+/−
Farmer's group membership	Dummy	+

Nominal variables and measurement levels used in the regression model.

The multinomial logit (MNL) model for climate change adaptation choice specifies the relationship between the probability of choosing alternative options as shown in Equation (2):

$$\Pr(Y_i = j) = \frac{e\beta j X_u}{1+\sum_{m=0}^{n} e^{\beta m X_{ij}}}, j = 0, 1, 2, 3, n \qquad (2)$$

where β_j is a vector parameter that relates the socio-demographic characteristics X_i to the probability that $Y_i = j$, (Greene, 2000). Six (6) key climate-smart practices were consolidated into four nominal levels that corresponded to prevalent community-based climate-smart practices in the agroecological zones. Because the probabilities of the six (6) main community-based climate-smart practices must sum to one, a convenient normalization rule is to set one of the parameter vectors, say β_0, equal to zero ($\beta_0 = 0$). The probabilities for the six alternatives then become, (Equation 3 and 4):

$$P_j = \Pr(Y_i = y) = \frac{e_\beta j X_{ij}}{1+\sum_{m=0}^{n} e_{\beta_m X} u}, j = 0, 1, 2, 3, \dots, n \qquad (3)$$

$$p^0 \equiv \Pr\,(Y = 0) = \frac{1}{1+\sum_{m=1}^{n} e\beta m X_u} \qquad (4)$$

The estimated parameters of a multinomial logit system are more difficult to interpret than those in a bivariate (or binomial) choice model. Insight into the effect that the explanatory variables have on the community-based climate-smart practices choice can be captured by examining the derivative of the probabilities with respect to the kth element of the vector of explanatory variables. These derivatives are defined in Equation 5 as:

$$\frac{\partial Pr\,(Y=j)}{\partial X_{jk}} = P_j\left[\beta_{jk} - \sum_{m=0}^{n} \Pr\,(Y_i = m)\beta_{jk}\right] j = 0, 1, 2, \ldots, n; k = 1, .k. \quad (5)$$

Clearly, neither the sign nor the magnitude of the marginal effects needs to bear any relationship to the sign of the coefficients. The Yi is the probability of adopting the community-based climate-smart practice. The following are the main community-based climate-smart practices used among the avocado smallholder farmers:

- No adaptation (base category for combined data),
- Intercropping with crop cover,
- Agroforestry interventions,
- Grass strips, and mulches,
- Manure/compost/green,
- all above practices.

The nominal variables were soil conservation practices such as intercropping, grass strips, mulches, manures, and agroforestry, such as planting avocado with other crops or livestock. The multinomial logit findings can be represented as relative risk ratios (RRRs), which reveal the link between predictor variables and community-based climate-smart practices (Obi and Maya, 2021). The data was used to fit the combined data set to make a policy recommendation based on collective behaviour rather than climate-smart practices. The analysis also tested the model adequacy of the three agroecological zones data, using the McFadden Pseudo R2 and the Likelihood Ratio Chi-Square Test (Krieger et al., 2018). The study considered the adoption of community-based climate-smart practices by avocado smallholder farmers in each agroecological zone to detect any ecological effect on the pattern exhibited by the smallholder farmers. The data were then combined for the entire sample of 282 respondents to determine the average avocado farmer's adaptation behaviour patterns by zone.

3. Results and discussions

The data findings portray the information on farmers' socio-demographic characteristics and the types of climate-smart practices.

3.1. Socio-demographic characteristics of the avocado farmers in the Upper Mara watershed

This section describes the socioeconomic and demographic characteristics of smallholder farmers in the Upper Mara watershed's three agroecological zones. The descriptions follow Wheeler et al. (2020), who argued in their research report on the modeling of farmers' climate, water, and socio-economic drivers that in agricultural information use studies, farmers' socio-economic and demographic characteristics are important metrics to better understand their contribution to information use, especially because of climate change. The findings are based on descriptive statistical analysis, which included the use of frequency tables and figures. The descriptive analysis results are shown in Table 2. The results present details on the gender, age, educational distribution, and marital status of the household heads, the farm size of the household heads, the years in avocado farming and avocado planting techniques on their farms.

Table 2. Socio-demographic characteristics of the sample (n = 282)

Gender			**Age**			**Education level completed**			**Marital status**			**Size of the farm (Ha)**			**Number of years in avocado planting**			**Avocado planting techniques**		
	n	%		n	%		n	%		n	%		n	%		n	%		n	%
male	202	35.11	<40	99	35.11	Not completed primary	55	19.5	Single	14	5	0.1-1	18	9.6	<1 year	18	15.1	Mixed cropping	84	29.9
Female	75	24.46	41-50	69	24.46	Completed Primary	97	34.4	Married	256	90.8	1.1-2	48	25.7	1-3 years	30	14.6	Pure stand	99	35.2
			51-60	60	21.28	High school/Diploma	120	42.6	Divorced	1	0.4	2.1-3	37	19.8	4-6 years	114	55.6	Boundary	7	2.5
			>60	54	19.15	First-degree & above	10	3.5	Widow(er)	11	3.9	>3.1	83	44.4	>6 years	28	13.7	Alternate rows	43	15.4
			Mean Standard deviation		(47.513) (13.32)								Mean Standard deviation	(3.98) (3.55)						

Results from SPSS (Version 26.0) generated from field survey, 2022 (Source: Author)

3.1.1. Gender and marital status

The results show a higher male representation of 72.9 percent of respondents, whereas female respondents were 27.1 percent, and they are involved in avocado farming (Table 2). This means that the majority of avocado farmers in the Upper Mara watershed are men. Avocado farming is a labour-intensive agricultural activity. According to the gender division of labour, certain farm activities are reserved for men and male youth. Thus, in terms of labour division, women preferred working on other food crops first to ensure household food security, whereas men ventured more into avocado farming. Gender, according to Malapit et al. (2020), is an important construct in information learning and sharing, as well as decision-making at the household and farm levels, particularly in relation to production factors and the adoption of climate-smart practices. Gender is a source of knowledge and power disparities that shape stakeholders' behaviour and can be used to organize innovation. In their work on gender roles, Kingiri (2013) and Malapit et al. (2019) argued that the gender dimension of agricultural production is exemplified by the roles and activities undertaken to address social and economic needs through agricultural production systems. Moreover, gender plays a critical role in agricultural and rural innovations (Iradukunda et al., 2019 and Kingiri, 2010), especially in the adoption of climate-smart practices, thus the need to engender conservation agriculture innovation processes.

According to the marital status results, the majority of respondents (90.8 percent) in the study area were married, 3.9 percent were widows/widowers, and only 5% were single. These findings indicate that most avocado farming was done by married farmers. Marital status has an impact on gender roles such as land use decision-making, labour division, and participation in farming processes. Marriage imposes familial responsibilities on individuals, making their participation in socioeconomic networks more serious in terms of access to more information and income to meet their responsibilities (Carr et al, 2020). The use of agricultural information is strongly related to marital status (Obi and Maya, 2021). Furthermore, married farmers are likely to face pressure to produce more, not only for family consumption but also for sale. The desire to produce more could lead to the acquisition and application of agricultural information. Similarly, the availability of family labour could be an incentive for the married farmer to cultivate more crops and use agricultural information/innovations (Friedman et al., 2019). Interactions with avocado smallholder farmers revealed information about the most prominent actors as well as information-sharing relationships, highlighting key gender differences. Women demonstrated greater information connectivity with family and friends, taking advantage of close-knit networks. In contrast, the men's network demonstrated the ability to connect external information sources such as media, community leaders, church groups, and friends and family (Friedman et al., 2022). To ensure equitable communication and use of information for climate-smart practices, it is critical to strike a balance between the family network's strong bonding and open exchange aspects, as well as consider the primary sources and perceived barriers to access and use of this information (Lawson et al., 2020).

3.1.2. Age and education level

As a moderator variable, age may influence both household and farm-level decisions regarding the adoption of climate-smart practices, as well as those that underpin empowerment, such as membership in farmer groups, leadership roles, and societal participation. Table 2 depicts the age groups of avocado-growing farmers. The results showed that the average age of avocado farmers was 47.53 years old, with a standard deviation of 13.32. As a result, the majority of avocado farmers were between the ages of 34.21 and 60.75, which is considered the productive farming age in rural communities. The elderly made up only 19.15 percent of the population, while the young made up 35.11 percent. As a result, younger farmers outnumber the elderly. As a result, age had an impact on the learning, adoption, and application of avocado farming as a climate-smart practice. In agriculture, age influences information acquisition and adaptation strategies (Carr et al., 2020 and Lawson et al., 2020). Earlier empirical studies established that, in normal circumstances, older farmers are less likely than younger farmers to accept new agricultural technologies, particularly when the technology is knowledge-intensive and labor-intensive (Friedman et al., 2022).

According to the results, the education level of avocado farmers in the Upper Mara watershed was 19.5 percent for those who did not have any formal and never completed primary, 34.4 percent for those who had a primary level, 42.6 percent for those who had a high school or diploma level, and 3.5 percent for those who had higher levels of education. Furthermore, the results in Table 10 indicate most of avcoaco farmers had obtained primary school certificate, hence the literacy levels among smallholder avocado farmers were moderate. This finding is consistent with previous findings by Khandker and Thakurata (2018) and Ugochukwu (2018), who argued that farmer illiteracy leads to a lack of choice, which is largely attributed to insufficient (or lack of) technical, epistemological, or prudential knowledge. As a result, an illiterate farmer is less likely to adopt improved agricultural technology than a literate counterpart. Similarly, Aldosari, et al. (2019) made a similar observation, stating that education of smallholder farmers is one strategy for dealing with farming constraints such as diseases.

Education level is an important factor because activities such as learning, sharing, and implementing technologies necessitate some level of comprehension. According to Kilelu et al. (2011), to effectively participate in the interactive learning processes in the innovation platform geared toward the adoption of climate-smart practices, innovations require a combination of hardware, software, and orgware. More recent studies by Obi and Maya (2021), stated that education enables individual farmers to seek and apply information on climate-smart practices. Similarly, Setshedi and Modirwa (2020), observed that farmers with a higher level of education tend to be more efficient in the adoption of new farming techniques since they are equipped with the ability to perceive, interpret, and respond to new information and improved farming innovations much faster than their counterparts. However, a lack of education may not prevent smallholder farmers from being active participants in development. In this case, information was sought from respondents regardless of their level of formal education. This informed the researcher about the respondent's ability to learn, share, and integrate the avocado fruit tree as a climate-smart practice. Farmers with any level of awareness, basic literacy levels, and above were expected to benefit from the action learning process and build their capacity to innovate in the context of innovation systems (Kingiri et al., 2013 and Friedman et al., 2022).

3.1.3. Farm size and planting techniques

The results indicate that in the Upper Mara watershed across the three agroecological zones, the average farm sizes vary between 0.1ha to greater than 3.1 ha with 0.1- 1 ha being 9.6 percent, 1-2 ha, 25.7 percent, 2.1-3, 19.8 percent and 3.1 ha and more being 44.8 percent. This, therefore, shows that 55.2 percent of the farmers possess farm sizes less than 3.1 hectares and 44.8 percent had more than 3.1 percent. The size of the land holding is a major challenge for smallholder farmers in the adoption of new technology and practices. Due to growing population pressure and the limited availability of unexploited land the size of cropland per capita has been decreasing. Farm size plays a critical role in the adoption of climate-smart practices (Fayso, 2018). Farmers with larger farms were found to be more likely to adopt climate-smart practices since they could use one part of the farm for trying new techniques and the other part for conventional practices (Fentie and Beyene, 2019). In contrast, farmers with small farms are hesitant to apply climate-smart practices, since they are afraid of the uncertainty of obtaining the claimed benefit. This confirms the findings reported by Mutoko et al. (2015) that land pressure leads to land degradation and reduced agricultural productivity for many smallholder farmers.. Farm size is often one of the first factors measured when modelling adoption processes. Empirical studies have consistently shown farm size to be significantly related to the adoption of new technology (Makate et al., 2018).

The results on the planting techniques on smallholder farms across the three agroecological zones show that 29.9 percent practice mixed cropping, 35.2 percent pure stands, 2.5 percent on the boundary and 15.4 percent plant avocado on alternate rows. These planting techniques were used by smallholders not with technical know-how but mainly for their convenience. Agroecological zones are based on climatic factors such as temperature, altitude and amount and distribution of rainfall. Some climate-smart practices are more suitable such as integrated nutrient management. Others are more effective where soil moisture needs to be conserved, e.g., conservation tillage as reported by Makate et al., (2018). Furthermore, changing rainfall patterns in combination with warming trends make agriculture riskier in the Upper Mara watershed and increases the demand for specific, locally adapted agricultural knowledge and technologies. research and extension services (Mutoko et al., 2015). New research and technology must not result in neglecting indigenous knowledge, which is also needed to make agriculture sustainable for smallholder farmers. The planting technique and the number of years (planting duration), in farming activities, had a positive relationship with the probability of farmers growing on pure stands, alternate row planting, boundary planting or mixed cropping rotation, with significance ($p < 0.05$) influencing the adoption of applying organic manures (compost and green) as climate-smart practices. As illustrated in Table 2, the choice of farming technique is used to increase the probability of planting practices on smallholder farms.

This study found that social capital and social networks positively and significantly affected household choice in applying climate-smart practices. Social capital in the Upper Mara watershed is mostly in the form of group participation, including women's groups, farmer group cooperatives, agricultural cooperatives, and the farmer. Participation in local organizations with collective actions could help reduce climate change risk through knowledge sharing, group avocado planting, forest protection through community forest associations, water management through the activities of water resource users' associations, and avocado contract farming in meeting market requirements.

3.2. Community-based climate-smart practices in the Upper Mara Watershed

In the Upper Mara watershed, the most important climate-smart and conservation practices are grass strip cropping, mulching, mixed cropping, intercropping, crop rotation, and agroforestry. The evidence suggested that existing climate-smart practices were far more complex than this study may have suggested, giving the impression that smallholders can make clear-cut decisions about the practices they adopt. Farmers may appear to be able to adapt a wide range of practices at the same time, particularly in the multi-enterprise environments in which many of them operate. Significant predictors of smallholder farmers' adapted climate-smart practices in this study included age, gender, number of years in farming activities, planting techniques, production and conservation training, and membership in farmer organizations.

The results indicate that the level of education and training on avocado farming for the avocado farmer had a positive effect on the intercropping with cover crops and agroforestry interventions by the smallholder farmers in the Upper mara watershed. The number of years spent in school acquiring education positively and significantly ($p < 0.05$) influenced the decision to adapt to climate-smart by using the application of agroforestry interventions and intercropping with cover crops as a coping strategy against climate change. Onyeneke et al. (2018), reported that educational attainment is similarly influential in the decision to adopt CSA practices in Nigeria. Similarly, Abegunde et al. (2019), reported that the educational level of respondents positively influenced the adoption of CSA practices. This finding also agrees with international experience that suggests that education enhances the opportunities to access new information that contributes to skills and know-how to apply improved technologies (FAO, 2020). This implies that as the farmer's educational level rose, they were more likely to prefer climate-smart practices. It is believed that more years spent acquiring knowledge expose the farmers to more information, thereby making it easier for them to make informed choices as well as increasing the chance of using new technology, as they understand more clearly.

Table 3. Parameter estimates of the multinomial logit (MNL) analysis of factors affecting the adoption of climate-smart practices in the Upper Mara watershed.

Independent Variables	Grass strips and mulches		Agroforestry interventions		Intercropping with cover crops		Applying manure/compost/ green		All Strategies	
	Coefficient	Sig	Coefficient	Sig	Coefficient	Sig	Coefficient	Sig	Coefficient	Sig
Intercept	3.074	0.916	1.414	0.522	−3.476	0.092	−0.617	0.628	2.145	0.540
Gender of HH	-0.530	0.269	-0.231	0.670	-0.946	0.064 *	0.708	0.144	−0.603	0.287
Age of HH	0.043	0.805	−0.518	0.009*	0.098	0.624	−0.049	0.776	0.177	0.555
Education level of HH	−0.293	0.100	0.128	0.536	0.469	0.021*	−0.303	0.106	−0.298	0.190
Farm size	0.617	0.628	-1.075	0.354	2.080	0.152	-0.617	0.628	−1.097	0.440
Planting duration	-0.273	0.100	0.108	0.669	-0.143	0.554	0.713	0.007*	0.309	0.558
Training	-0.295	0.122	−1.789	0.002*	-0.670	0.151	0.450	0.256	0.8.0	0.133
Access to extension service	−0.184	0.477	−0.119	0.606	-0.229	0.436	0.184	0.477	0.149	0.499
Membership group	-2.75	0.122	6.55	0.108	0.456	0.195	-0.549	0.075*	0.484	0.125

*Source: Results from SPSS (Version 26.0) generated from field survey, 2022., ** = values statistically significant at 0.05 probability level, * = values statistically significant at 0.10 probability level. The number of respondents: 282*

According to Table 3, the age of the household head was significant in all the agroecological zones the results show that the age of the household head significantly ($p < 0.05$) influenced the adoption of climate-smart practices in the reference agroecological zone. This means that advancing age decreased the chances of adapting to new farming practices by smallholder farmers in the upper agroecological zone, probably by 1.77%, compared to using agroforestry, grass strips and mulches, and intercropping practices. Likewise, for farmers in the mid zone, age had a higher adoption of agroforestry interventions at the relationship for the same reasons ($p < 0.05$) compared to selecting grass strips and mulches, intercropping and application of manures, at a frequency of 5.18 percent. This shows that younger farmers had a greater ability to cope with the changes in climate than the older farmers.

The results show that trained smallholder farmers who were currently using organic manure were more likely to shift to the alternative options (perhaps the agroforestry interventions), as much as farmers heading larger households and owning larger farms. The possible reasons could be that agroforestry interventions need more technical know-how than conventional farming and are an undertaking best operated by informed and younger avocado farmers. The results indicate that the training on conservation activities positively and significantly ($p < 0.05$) influenced the decision to adapt to climate-smart by the younger farmers to use agroforestry interventions. It also shows a negative relationship to adopting agroforestry intervention by the older avocado farmers with a negative coefficient with a strong significance in table 3. This study has demonstrated that the group or participatory-based approaches have the potential to encourage interactive learning between different actors, for instance, extension agents and farmers.

Access to extension services to the household head significantly ($p < 0.05$) influenced the choice of adapting to climate-smart practices by using soil and water conservation practices, compared to using organic manures. This implies that when the household head's accessibility to farming information, the probability of adapting to climate-smart practice by using grass strips and mulches, agroforestry interventions, and intercropping with cover crops was higher by 14.9%, compared to applying organic. This means that households whose livelihoods depended on farming were more invested in activities that would improve their production and therefore were able to explore several climate-smart practices. However, Kingiri (2021), pointed out that t for an efficient agricultural advisory and extension service (AES) is poised to lead to improved agricultural productivity as farmers utilize information and knowledge to optimize their use of limited resources. Nevertheless, the role of AES has progressively evolved due to the changing technological, economic, and social context, though in the study area, it negatively impacts the smallholder farmer in Upper Mara due low level of accessibility.

The results in (Table 3) show that membership in a farmers' association could be significantly ($p < 0.05$) associated with a tendency not to change existing practices in preference for new climate-smart practices. A negative coefficient and weak significance were observed where household heads reported membership in a farmers' association concerning the use of organic compost on their farms; the negative coefficient suggests that they were more likely to adopt other climate-smart practices. It is expected that being part of a farmers' group provides agricultural information, services, and resources useful for adapting to climate change, but in this study, the converse is true, where the household head had perceived security to continue with old ways. The results suggest that those who currently use organic manure in their farms were likely to prefer it to all other community-based climate-smart options if they were older and were members of farmer groups. Thus, there need have ways for getting information to the smallholder farmers. The revolution in information communication technology (ICT) and related innovation has been perceived to hold promise in enhancing the delivery of timely and relevant information to farmers in a rural agricultural innovation system, especially in emerging economies (Barber et al., 2016). Some of the ICT approaches or tools include TV, radio, and mobile phones including smartphones with provision to use internet services. These tools have multiple functionalities that include information dissemination, training, and linking partnerships among the stakeholders (Saravanan et al. 2015).

Community-based climate-smart practices can be that vegetation is used, either alive or dead, in sufficient quantities to shield the soil surface from the direct impact of raindrops and to create a rough surface which will physically impede run-off and slow it down to non-erosive velocities (Eshetu et al. 2021). The role of climate-smart practices to reduce land degradation has immense importance. Understanding and disseminating the different climate-smart practices used to cultivate the soil and grow the crops (Rosenstok et al., 2016). The biological climate-smart practices utilise the role of vegetation in helping to minimize erosion by increasing soil surface cover, surface roughness, surface depression storage and soil water infiltration and retention (Rosenstock et al., 2016). According to Nyasimi et al. (2017), climate-smart practices undertaken within the cropping area for crop production purposes and including practices such as grass strips, agroforestry interventions, intercropping with crop and green manuring, contour cultivation, minimum tillage, mulching, manuring, and composting, etc., which are usually associated with crop production, are repeated routinely each season or in a rotational sequence, are of short duration or permanent.

Promoting farm resilience in the Upper Mara watershed not only indicates keeping the land in proper productive condition by maintaining soil fertility (Leyew et al., 2021). In doing so, climate-smart practices control erosion, maintenance of organic matter and soil physical properties, maintenance of nutrients, and avoidance of toxicity (Mcharo and Maghenda, 2021). Therefore, the community-based climate-smart practices provide a protective role. This is through its prevention of soil from loss by its plant canopy, litter effect, and reduction of the velocity of runoff mechanically by runoff barrier function (Arif et al., 2020). This can be viewed in its interception effect, i.e., the plant canopies, litter, and mulching intercept rain by decreasing the amount, intensity and spatial distribution of the precipitation reaching the soil surface (Arif et al., 2020; Mwenge et al., 2021). This protects the soil surface from the direct impact of raindrops which can cause a splash and sheet erosion, a breakdown of the soil structure, sealing of the surface and reduction of infiltration rates (Leyew et al., 2021). And at the same time leads to built-up soil organic carbon that brings out soil health and resilience in a sustainable way.

4. Conclusions and recommendations

Smallholder farmers in the study areas were affected by various climate change-related shocks, including droughts, decreased rainfall, and floods. These farmers also faced limited access to essential resources like extension services, credit, and farm inputs. However, some farmers were able to use indigenous knowledge to counteract the effects of climate change. Despite adaptation strategies being available, not all farmers have adopted them. This highlights the need for policymakers to implement more community-based and efficient systems that release farmers from their low-level equilibrium traps.

On the other hand, avocado farmers showed a positive response and motivation towards practicing climate-smart farming. They achieved this through various techniques such as planting different plant varieties, crop rotation, altering planting dates, and using cost-effective methods. Climate information exchange played a critical role in helping these farmers adapt to climate change threats.

The study also found notable gender differences within the farming community. Women relied on close-knit networks, while men preferred external sources to connect with friends and family. To promote conservation practices in the Upper Mara watershed, farmers adopted techniques such as grass strip cropping, mulching, intercropping, crop rotation, and agroforestry. These practices helped decrease the intensity, amount, and spatial distribution of precipitation reaching the soil surface by intercepting rain through plant canopies, litter, and mulching.

Overall, adaptation strategies can help under-resourced farmers cope with climate change-related shocks. However, not all farmers adopt these strategies, which is why policymakers must implement community-based and efficient systems. Additionally, promoting climate-smart farming practices and providing climate information exchanges can help farmers adapt to climate change threats. Addressing gender differences and promoting conservation practices are also essential in building resilience to climate change in farming communities.

The study recommendations are:

- Climate-smart training will be an important capacity-building tool for disseminating climate-smart practices and targeting the knowledge of advisory service providers. It is necessary to receive hands-on training in soil nutrient management, compost preparation, and water harvesting techniques.

- The availability of financial assistance services will have a significant impact on smallholder farmers' decisions to use climate-smart practices. Farmers should be frequently trained on their credit-use rights and the obligation to repay on time when they receive financial assistance.
- The Ministry of Agriculture and Livestock Development should formulate a policy structure to support climate-smart policies on the use of fruit crops in conservation agriculture. This is essential for the spread of climate-smart practices in the County, as the effects of climate change can hamper progress so far. Since this study employs the multi-stakeholder approach, then, there is a need for the investigation of the long-term viability of multi-stakeholder innovation platforms for driving agricultural technology adoption of climate-smart practices among smallholder farmers.

Author contributions

All authors conceived the idea and contributed to the planning; Simon Rop undertook the literature searching and analysis and lead the writing; all authors contributed critically to the drafts and gave final approval for publication.

Declaration of competing interests

The author(s) of this article have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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