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Regular Article

Supporting smallholder livestock farmers' adaptive capacity to climate change in Kenya: What role does entrepreneurial orientation and uptake of CSA play?

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ABSTRACT

Improving smallholder farmers' adaptive capacity to climate change has become a major concern of governments and development agencies. Adaptive capacity determines the inherent ability of a system to cope with vulnerability to climate change. This paper used cross sectional survey data of 737 livestock producing households to assess determinants of adaptive capacity among Arid and Semi-Arid (ASAL) communities in Kenya. Specifically, we focused on the role of entrepreneurship orientation (risk taking, proactiveness and innovativeness) and uptake of climate smart agricultural (CSA) practices in improving adaptive capacity – a dimension which has received limited research attention. Adaptive capacity was measured using a set of indicators representing the five capitals in the Sustainable Livelihood Framework (SLF). The determinants of adaptive capacity were analyzed using fractional and censored regression models. The results revealed mixed influence of entrepreneurship orientation on adaptive capacity. While risk taking and proactiveness were positively associated with a higher adaptive capacity, innovativeness did not have any influence. Similarly, uptake of livestock CSA practices was associated with a higher level of adaptive capacity. Other factors that positively influenced adaptive capacity were age, gender, education level, diversity of income, access to extension services, credit, and collective action. The findings suggest that a strategy to promote entrepreneurial orientation, uptake of CSA, accumulation of human and financial capital would enhance livestock producers' adaptive capacity.

1. Introduction

The report by Intergovernmental Panel on Climate Change (IPCC) shows that the rapid and uncertain changes in earth surface temperature and rainfall patterns are likely to exacerbate the vulnerability of the agricultural systems globally [1]. While the impacts of climate change are global in nature, negative impacts on agriculture and food systems are projected to be severer in Sub-Saharan Africa (SSA) [1]. The region's vulnerability lies in the fact that agriculture and livestock production systems, which dominate their economies, are mainly rain-fed and therefore highly sensitive to climate change [2]. SSA's situation is made worse by the rising poverty levels, low adaptive capacity, and weak institutional and economic capacity [1].

Kenya, is particularly vulnerable to adverse effect of climate change and shocks, because of its high dependence on agriculture that is a climate-sensitive economic sector [2]. Erratic rainfall patterns coupled with prolonged droughts have complicated the hunger situation, especially in Arid and Semi-Arid areas (ASALs), where livelihoods depend principally on natural resources [3–6]. Kenya's ASALs host about 75 % of the country's total livestock - which is a key source of livelihood for over 10 million people [7]. Moreover, farmers in these regions are further predisposed to food insecurity and poverty associated with loss of productive assets and weakening of coping strategies [5]. Households in these regions continue to be more vulnerable because of low technical and financial capacity to adapt to climate change [8].

Climate Smart Agriculture (CSA) practices have been promoted as one of the approaches for building resilience and mitigating against negative climate change impacts [9–11]. The potential of CSA is derived from its ability to integrate the key dimensions of sustainable development (social, economic and environmental) through its three main

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objectives; sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change, and reducing greenhouse gas emissions [10]. In promoting CSA, the government has put in place policies aiming at reducing the impact of climate change on agriculture and livestock systems and improving the adaptive capacity of farmers [12–16].

A wide body of literature exists in assessing the role of CSA in achieving its triple objectives [17–22]. However, existing studies appear to concentrate on productivity and household welfare outcomes ignoring the enhancement of adaption and resilience [23–26]. This is despite the recognition that CSA also helps to increase adaptive capacity as means for achieving resilience [27–30]. Similarly, the literature has paid more attention on the effects of socioeconomic and institutional characteristics on adaptive capacity [11,22,31]. There is minimal research attention on cognitive factors – which are behavioural or psychological in nature and can influence farmer decisions towards climate change adaptation [32, 33]. In addition, the emerging body of work on adaptation to climate change in SSA, have focused mainly on crops [11,31,34–37], with limited attention to agropastoral livelihoods [38,39].

This article examined the factors influencing farmers' adaptive capacity to climate change within ASAL communities, focusing on smallholder livestock producers. Specifically, we analyzed the impact of farmers' entrepreneurial orientation (EO) and the adoption of CSA practices on adaptive capacity. Our contribution to the literature is threefold. Firstly, we utilized the sustainable livelihood framework to develop a comprehensive metric for assessing adaptive capacity, incorporating key dimensions crucial for resilience-building among the pastoral communities. Understanding adaptive capacity among policy makers and development practitioners is considered a foundational step in building resilient and sustainable systems for coping better with climate change and variability.

Secondly, we draw on data from highly vulnerable smallholder livestock producers, to show the significance of entrepreneurial orientation (EO), which encompasses risk preferences, innovativeness, and proactiveness of smallholder farmers in addressing climate change challenges [32,33]. Risk taking is reflected in the willingness of the farmer to commit significant resources for the adoption of practices. Proactiveness on the other hand, signifies the ability of the farmer to interpret the weather changes and act to avert or minimize the consequences of the environmental changes expected. Innovativeness is the tendency to engage in practices and technologies which deviate from traditionally known practices. By highlighting the role of EO, we underscore the importance of considering cognitive factors in the design of climate change interventions, especially within the context of the growing policy recognition that pastoral communities in Africa's vast rangelands require support to transition from subsistence to market-based systems.

Thirdly, we linked the uptake of CSA practices with adaptive capacity in the context of pastoral livestock production systems in an ASAL areas, an undertaking that has received little attention to date. Our study also fills a notable gap in the literature by focusing on livestock, an area that is often overlooked compared to climate change studies in crop systems [11,31,34–37]. By addressing this oversight, we contribute to promoting a more comprehensive understanding of resilience-building processes that encompass both crop and livestock sectors.

This paper therefore addressed the existing knowledge gaps by assessing the role of livestock farmers' entrepreneurial orientation (EO) as well as the contribution CSA adoption on the adaptive capacity. Specifically, the paper sought to; i) assess livestock farmers adaptive capacity in ASAL regions of Kenya; and ii) estimate the influence of entrepreneurial orientation (risk taking, proactiveness and innovativeness) on livestock farmers' adaptive capacity and iii) determine the contribution of CSA uptake on adaptive capacity of livestock farmers in ASAL regions of Kenya. Findings from this study provide policy recommendations for increasing adaptive capacity of pastoral communities through a change of mindsets. This is particularly important since pastoralist communities have a strong culture of preserving livestock for subsistence and prestige rather than for commercial value.

2. Materials and methods

This section provides an overview of the conceptual framework applied in the study, a description of the study area, data and sampling and the estimation strategies.

2.1. Conceptual framework of this research

This article borrows from sustainable livelihood framework [40] that explores how a household allocate its assets to different livelihood strategies in a vulnerability context. Pastoralist households are more vulnerable to climate change threats and other shocks, which are often beyond their direct control.

The graphical representation (Fig. 1) of the framework revolves around three interconnected components: livelihood capital assets, livelihood strategies, and livelihood outcomes. The framework first identifies the main assets of households which encompass natural, physical, human, social and financial capitals. Natural capital assets entail access to land and water resources while physical capital assets include ownership and type of housing and, access to quality infrastructure. Human capital assets encompass livestock farming experience, educational attainment, household size and access to extension services. Social capital assets relate to collective action and holding leadership roles and, financial capital assets include access to credit and engagement in off-farm activities. These assets are crucial for resilience of pastoralists who face poor access to most of these capitals.

The second component is livelihood strategies such as livestock production, crop farming, wage employment and ecosystem extraction [40, 41]. Households select their livelihood strategies based on their endowment of capital assets. To reduce vulnerability and increase resilience, pastoral households have employed traditional risk-management strategies like livestock accumulation, herd movements depending on rainfall patterns and herd dispersion. Over time, these strategies have broken down in the face of extreme weather events, growing human population and environment degradation. This is compounded by the fact pastoral systems are yet to embrace more commercial and market-based risk strategies as such as offtake.

To transition from subsistence to market-based systems, we hypothesize entrepreneurial orientation (EO) as a key component for resilient building among households. This encompasses their willingness to take risks (committing resources to uncertain outcomes), embracing innovation (readiness to depart from traditional practices) and proactiveness (capacity to anticipate and address climate change challenges. Therefore, households with a high EO can combine different capitals and practices to increase uptake of CSA practices and therefore increase adaptive capacity [10,42,43]. In turn, household development of adaptive capacity is reflected in their ability to accommodate or cope with climate change with minimal disruption. In our analysis we measure adaptive capacity using the household's capital assets endowment. The more the capital assets, the better the strategies and the higher the adaptive capacity. High adaptive capacity can lead to desired livelihood outcomes (third component) such as reduced vulnerability, increased income, improved well-being and increased food security).

2.2. Description of the study area

The study was conducted in Laikipia (0° 21′ 38.2″ N; 36° 46′ 55.2″ E), Taita Taveta (3° 18′ 57.7″ S; 38° 29′ 6″ E) and Kajiado (2° 5′ 53.2″ N; 36° 46′ 55.2″ E) counties, which are the ASAL counties of Kenya where households are mainly involved in livestock-based livelihoods (Fig. 2).

The study counties represent varying levels of vulnerability to climate change, reliance on livestock-based livelihoods and variability on agro-ecology. Kajiado County has a total area of 21,871.1 km^2 with a human population of 1,117,840 [44]. According to the National Census report

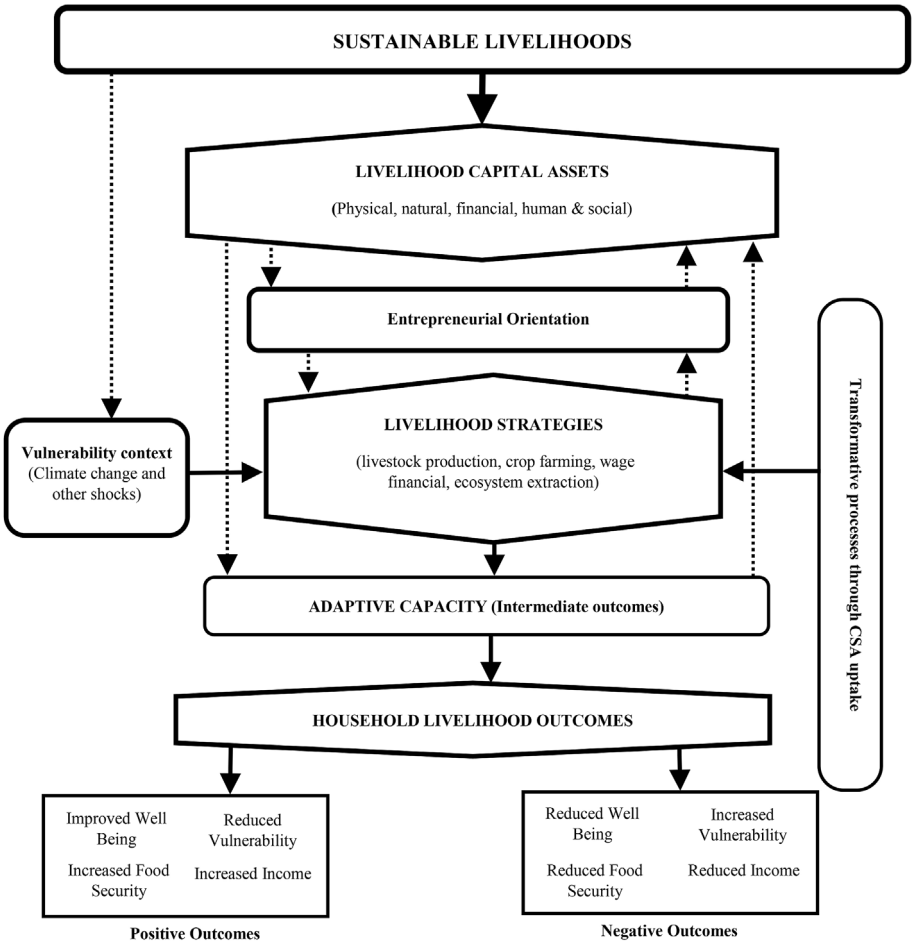

Fig. 1. The graphical representation of the conceptual framework used in this study.

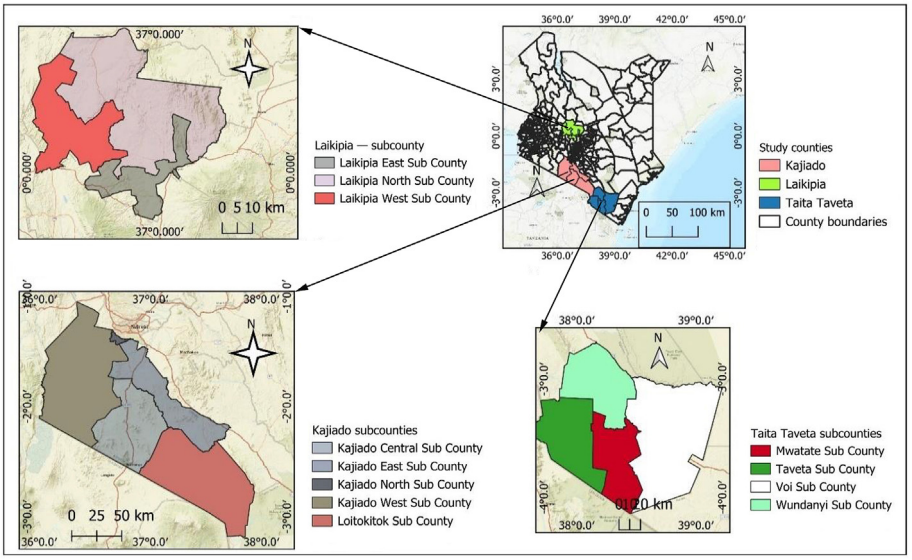

Fig. 2. The map showing the study area (Laikipia, Taita Taveta and Kajiado Counties).

2019, the county is ranked the second and fifth with regards to the population of cattle (557,710) and sheep (1,120,649) respectively among the ASAL counties. Laikipia County has a total area of 9462 km^2 and a human population of 513,879 with livestock population distributed as follows; cattle 270,065, goats 402,526, sheep 613,782 and camels 7827. Taita Taveta has a human population of 340,671 and a total land coverage 5, 876 km^2 for farming. The livestock distribution within the county is 114,814 cattle, 46,535 sheep, 202,113 goats and 2938 camels.

2.3. Data collection

The study employed a four-stage procedure on data collection. First, three counties (Kajiado, Taita Taveta and Laikipia) were purposely selected to represent varying levels of vulnerability to climate change as shown: Laikipia = 0.384, Kajiado = 0.426 and Taita Taveta = 0.437 [45–47]. Secondly, three sub-counties were selected from each county based on their differences in livestock-based livelihoods. Thirdly, two wards from each sub-county were selected based on the promotion of livestock related CSA practices as documented in the Kenya Climate Smart Agricultural Project (KCSAP) reports [2,48]. Finally, in the last stage, simple random sampling was used to select a total sample 737 smallholder livestock farmers for survey from lists generated from the selected wards. The field survey took place between July and September 2022. Structured questionnaires were administered to collect information on livestock farmers household and farm characteristics, entrepreneurial orientation information, knowledge or awareness of CSA and household vulnerability context. Others were, livelihood strategies, uptake of CSA practices, household capitals, and households' outcome variables such as food security status, income and welfare. To complement the survey, the study undertook six Focused Group Discussions (FGDs) and 15 Key Informant Interviews (KIIs). The selection of participants considered a number of characteristics, including gender, age, level of CSA use, county government representation as well as livestock, veterinary and animal health officers and agrovets dealers.

2.4. Estimation strategies

The study objectives were analyzed in two stages. The first stage measured the household adaptive capacity, entrepreneurial orientation (EO) and CSA uptake. In the second stage, the determinants of the adaptive capacity were analyzed using Fractional Regression Model (FRM).

2.4.1. Measurement of the household's adaptive capacity

Adaptive capacity (AC) was measured using a total of 20 indicators representing the five capitals in the Sustainable Livelihood Framework (SLF) [natural (3 items), physical (5 items), human (5 items), financial (5 items) and social (3 items)]. The indicators were selected based on a thorough literature review considering previous approaches for assessing adaptive capacity and qualitative interviews with experts in the study sites.

Following previous literature, the indicators were assigned scores, graduated based on their scale of measurement and importance in influencing the AC of the household [19–22,31,38,49,50] (as summarized in Table S1 in Supplementary data). Since the indicators had different scales of measurement, normalization of the scores was achieved using min-max method – where all the scores were converted to values ranging from 0 to 1 as per Equation (1).

$$X_i = -(X_i - X_{Min}) / (X_{Max} - X_{Min}) \quad (1)$$

Where X_i is the normalized score ranging from 0 to 1, X_i represents the individual rank point to be transformed, X_{Min} is the lowest rank value for that indicator, X_{Max} is the highest rank value for that indicator.

Using the normalized scores for the indicators, an aggregate score (ACS) for each of the five (5) capitals was calculated. The scores of the indicators in every capital asset were summed up to get a total score. Household index for every capital asset was then derived by dividing the total score by a maximum score expected for that capital asset as shown in Equation (2).

$$CAC_q = 1 / K\left(\sum_{i=1}^{m} S_{ij}\right) \quad (2)$$

Where CAC_q is the capital asset index for a particular capital asset (q); S_{ij} is the score of jth item for ith respondent; K is the maximum expected capital asset score based on the number of indicators considered in the capital asset and m is the total number of capital assets (m = 5 capital assets in this case).

Finally, the overall adaptive capacity (AC) was obtained by dividing the total score of the five capital assets for each household by five as shown in Equation (3), thereby reducing the adaptive capacity to a scale of $0 \leq AC \leq 1$.

$$AC_i = 1 / M\left(\sum_{i=1}^{m} CAC_m\right) \quad (3)$$

Where AC_i is the overall capital asset index for ith respondent; CAC_m is the capital index of mth capital asset category for ith respondent; M is the total number of capital assets used (in this case M = 5).

Using the calculated scores (Equation (3)), The AC of the household was categorized as follows; low adaptive capacity ($AC \leq 0.44$), moderate adaptive capacity ($0.44 < AC \leq 0.56$) and high adaptive capacity ($0.56 < AC \leq 1.0$), following previous literature [20,31,34].

2.4.2. Measurement of entrepreneurial orientation of livestock farmers

The entrepreneurial orientation (EO) of the livestock producing households was measured using 10 statements; risk taking (3 items), innovativeness (3 items) and proactiveness (4 items) (Table S2). Risk taking is reflected in farmers' willingness to commit resources for the adoption of innovations such as CSA practices. Proactiveness on the other hand, is the ability of the farmer to anticipate and act to avert or minimize the impact of environmental changes. Innovativeness measures the tendency to engage in technologies which deviate from traditionally known practices [33]. The statements were measured using a 5-point Likert scale (where a higher score represents increased levels of EO for positive statements and vice versa for negative statements). The scores for the negative statements (marked with superscript R in Table S2) were reversed to allow for calculation of EO mean or indices.

Principal component analysis (PCA) was used to generate household indices for each of the three EO Variables [32,33]. Kaiser-Meyer-Olkin (KMO) and the Bartlett's Test of sphericity and Cronbach alphas values were considered to assess the internal consistency, validity and reliability of the chosen items. KMO which measures sampling adequacy was above the recommended 0.5 considered satisfactory while the Bartlett's Test of sphericity was significant ($p = 0.000$) showing the need for factor analysis. The Cronbach alphas were all above the recommended 0.6 hence indicating a high degree of internal consistency among the constructs. All items loaded well in their respective dimensions and hence no item was dropped as shown in Table S2.

2.4.3. Measurement of uptake of CSA practices

The study considered 10 CSA practices (fodder conservation; water harvesting; regular vaccination; increased veterinary use; rearing adapted breeds; selecting adaptive breeds from own herd; keeping a variety of livestock; destocking or selling at the onset of drought; diversification into crop farming; Manure use or sale). The level of uptake was measured as a count of CSA practices adopted by a household in the year preceding the survey.

2.4.4. Assessment of determinants of adaptive capacity among the livestock farmers

To assess the factors that influence adaptive capacity of smallholder livestock farmers, we employed the fractional regression model (FRM) [51,52]. The model (equation (4)) was considered appropriate given the fractional nature of the AC indices which are bound within a unitary interval (0,1).

$$E(AC|X) = g(X\beta) \quad (4)$$

Where AC is the households' adaptive capacity index while X is a vector

containing EO, CSA uptake and other covariates assumed to influence adaptive capacity, β is the vector of parameters to be estimated (Table 5). In addition, $g(.)$ is a non-linear function satisfying the condition that $0 \leq g(X) \leq 1$ for all $Z \in R$ [51,52]. A censored regression model was used to check robustness of the results.

3. Results

3.1. Levels of adaptive capacity across the study areas

There were significant differences ($p < 0.01$) in the AC levels across the study counties (Table 1). The mean AC index of the study areas was 0.506, suggesting a medium AC. Households in Taita Taveta however, had the highest mean AC (0.553), compared to Kajiado (0.508) and Laikipia (0.452). The comparatively higher AC in Taita Taveta could be attributed to the county having more diversified livelihoods (e.g. agriculture) which would cushion households against climate change related shocks and threats [39]. These results compare well with previous studies which show low to medium levels of adaptive capacity among smallholders farmers [20,22,31,35].

Table 2 shows how adaptive capacity varies across household capitals. The comparison across was tested using one-way ANOVA (K-Wallis). The results show a higher AC among older and more educated farmers ($p < 0.05$). In addition, there are higher levels of AC among households with secure land tenure, higher access to credit, higher access to extension services and participation in collective action. Moreover, households engaging in agropastoralism had higher adaptive capacity than those with livestock rearing as their main source of livelihood. However, there were no significant difference in adaptive capacity across gender, household size, experience in livestock farming, ICT use and marital status. Livestock farmers should be encouraged to embrace more diversified sources livelihoods which can cushion them against climate change related shocks and threats.

3.2. Entrepreneurial orientation and uptake of CSA practices

The summary statistics show that the mean values across all the three components of EO were higher for the farmers with high levels of AC (Table 3). On average the sampled households were found to be more innovative with a mean of 3.8 as compared to being risk-takers (3.6) and proactive (3.2). Notably households with low adaptive capacity were found to be less proactive (2.9) as compared to household with high AC (3.5) and those with low AC (3.3) it was remarkable that household with high AC were found to be more risk-takers, proactive and innovators. This implies that such households were more likely to be first-movers in the adaptation strategies which will help them increase their adaptive capacity and build resilience to climate change [38,39]. A similar pattern is also observed for CSA uptake. On average, the sampled households adopted 5.3 out of a possible ten CSA practices. Households with higher adaptive capacity adopted more CSA practices (6.3), compared to those with moderate (5.1) and low (4.6) adaptive capacity levels. Thus adoption of CSA was positively associated with higher adaptive capacity levels [49,50].

Table 4 shows a more detailed comparison of the CSA adoption across the three levels of AC. The assessment shows the proportion of households who adopted specific practices across the three AC levels. The results show that households had higher levels of adoption (above 67 %) in livestock vaccination, use of veterinary services, rearing of adaptive breeds, diversification into crop production activities and collection of livestock manure either for sale or decomposing for farm use. However, the households with low levels of AC index had very low rate of adoption in some of the practices that were found to enhance adaptive capacity such as diversification into crop production (< 18 %) and fodder conservation (15 %).

3.3. Determinants of the adaptive capacity

Determinants of adaptive capacity were done using FRM (Table 5). A censored regression model was also fitted to check robustness. The results were found to be robust because both regression models posted similar patterns of significance and influence on the estimated variables. Diagnostic tests were performed to assess the validity of the model. The Variance Inflating Factor (VIF) technique (Table S3) showed that the model did not have a serious multicollinearity problem as all factors were below 10. Likewise, Ramsey RESET test for misspecification error was done and the null-hypothesis was not rejected ($p = 0.054$), meaning the model did not suffer from misspecification.

It was found that EO dimensions had varied effects on adaptive capacity (Table 5). Farmers risk taking was found to positively influence adaptive capacity. Farmers who take bold decisions to engage in practices that involve commitment of significant resources such as adopting livestock breeds which are more adaptable to climate change effects are more likely to have higher adaptive capacity. Engaging in risky investment practices can generate a stock of assets that can be used to overcome or minimize climate change shocks [53,54]. Previous findings shows that farmers within the ASAL regions are risk averse because of their cultural orientation where livestock are viewed with a social prestige lense and not commercial value [3,42]. Hence programmes that can influence change of mindset from subsistence to market-oriented production need be designed and implemented.

4. Discussion

Our results affirm that proactiveness positively influenced adaptive capacity. Proactiveness is a tendency to self-initiate a solution to a problem rather than react to it after it has occurred. This implies that proactive farmers were more likely to be the first to engage in practices such as conserving fodder and water, engaging in regular livestock vaccination, and selling of livestock at the onset of drought when the livestock are still in good form and weight. Providing accurate and timely information about expected weather changes can equip farmers to develop and introduce new proactive ideas and practices that can help them enhance adaptive capacity in face of climate change related shocks. These results affirm those of Andati et al. [32], who also found that risk taking and proactiveness positively influenced the uptake of certain CSA practices among the potato farmers.

Our findings showed that innovativeness did not influence the adaptive capacity of the livestock farmers. Innovativeness enabled the livestock farmers to deviate from societal or culturally established practices and technologies and embrace new adaptive practices.

Table 1
Levels of adaptive capacity (AC) across the three Counties.

		Kajiado n = 248	T/Taveta n = 258	Laikipia n = 231	Pooled n = 737	K-Wallis
		Mean/Percent	Mean/Percent	Mean/Percent	Mean/Percent	
Adaptive capacity (Mean)		0.508	0.553	0.452	0.506	0.0001
Adaptive Capacity (Frequency)	Low	25.00	20.16	57.14	33.38	0.0001
	Moderate	47.18	28.29	24.24	33.38	
	High	27.82	51.55	18.61	33.24	

Comparison of means based on Kruskal-Wallis rank sum test.

Table 2
Descriptive test statistics of difference among farmers with low, moderate and high adaptive capacity (AC).

Variable	Variable Measurement	Pooled n = 737	Levels of Adaptive Capacity			K-Wallis Test
			Low n = 248	Moderate n = 248	High n = 245	
		Percent/mean	Percent/mean	Percent/mean	Percent/mean	
Human Capital						
Age of household head	Years *(SD in brackets)*	48.74 (14.47)	45.45 (15.56)	48.68 (14.04)	52.11 (12.99)	0.0001
Gender of household head	Female	22.66	26.02	23.58	18.37	0.1183
	Male	77.34	73.98	76.42	81.63	
Household size	Number *(SD in brackets)*	5.21 (2.13)	5.17 (2.15)	5.18 (1.90)	5.28 (2.30)	0.5611
Education level of Household head	Primary	36.91	32.93	39.84	37.96	0.0001
	Secondary	19.54	14.23	17.48	26.94	
	Tertiary	10.18	3.66	9.76	17.14	
Marital status	Married	82.36	80.89	82.52	83.67	0.7655
	Never Married	5.97	7.32	5.69	4.90	
	Widowed	11.67	11.79	11.79	11.43	
Source of livelihood	Livestock rearing	63.50	78.05	69.51	42.86	0.0001
	Other sources	36.50	21.95	30.49	57.14	
Livestock farming experience	Years *(SD in brackets)*	19.45 (13.53)	18.85 (13.68)	19.46 (13.24)	20.06 (13.71)	0.4853
Access to Extension services	Yes	55.50	35.37	55.69	76.73	0.0001
Natural Capital						
Land Ownership	With title deed	47.22	19.18	52.44	70.20	0.0001
Access to community grazing land	Yes	29.72	25.20	30.20	33.88	0.0001
Financial Capital						
Household average monthly income	KES *(SD in brackets)*	15201.47 (16709.99)	12121.14 (13616.22)	14900.41 (15432.27)	18596.65 (19892.83)	0.0002
Types of livestock production system	Agro-pastoralism	24.69	10.98	17.07	46.12	0.0001
	Pastoralism	75.31	89.02	82.93	53.88	
Access to Credit	Yes	53.32	35.37	55.69	68.98	0.0001
Physical Capital						
Mobile Phone Ownership	Yes	67.98	80.82	82.04	83.33	0.7680
Social Capital						
Collective action participation	Yes	67.30	33.33	72.76	95.92	0.0001
County	Kajiado		25.00	47.18	27.82	0.0001
	Taita Taveta		20.16	28.29	51.55	
	Laikipia		57.14	24.24	18.61	

Comparison of means based on Kruskal-Wallis rank sum test (Standard deviation values in parenthesis).

Table 3
Description of entrepreneurial orientation (EO) and climate-smart agriculture (CSA) uptake across the levels of adaptive capacity.

Variable	Pooled n = 737	Levels of Adaptive Capacity			K-Wallis Test
		Low n = 248	Moderate n = 248	High n = 245	
	Mean	Mean	Mean	Mean	
Risk taking	3.6 (0.800)	3.3 (0.828)	3.7 (0.774)	3.9 (0.636)	0.0001
Innovativeness	3.8 (0.810)	3.5 (0.928)	3.8 (0.676)	3.9 (0.752)	0.0001
Proactiveness	3.2 (0.961)	2.9 (1.176)	3.3 (0.785)	3.5 (0.821)	0.0001
Total CSA adopted	5.3 (2.54)	4.6 (2.65)	5.1 (2.44)	6.3 (2.21)	0.0001

Comparison of means based on Kruskal-Wallis rank sum test.

Although there was no significant influence, we still conclude that innovativeness is not riskless since it requires money and creativity to apply. If farmers are not exposed to practical adoption of low-cost but high return technologies and practices, they are unlikely to be innovative. Therefore, there is a need to expose livestock farmers to more climate smart practices that are within their resource capacities to motivate them to embrace the change. These results are contrary to those of Kangogo et al. [33] who found innovativeness to positively influence the adoption of a number of CSA which are believed to contribute to high AC.

The number of CSA practices adopted by the household had a positive and significant effect on the adaptive capacity. Households who had adopted more CSA practices were more likely to have a higher adaptive capacity than those who adopted few CSA practices. The positive

Table 4
Adoption levels of climate-smart agriculture (CSA) technologies and practices per the level of adaptive capacity (AC).

CSA Practices	Level of adoption across AC Levels			Pooled (%)	K-Wallis Test
	Low (%)	Moderate (%)	High (%)		
Fodder conservation	15.0	19.5	26.9	20.5	0.0044
Water harvesting and storage	39.4	46.3	64.1	49.9	0.0001
Regularly Vaccinating livestock against key diseases	55.3	67.9	82.1	68.4	0.0001
Increased use of veterinary services	45.5	54.9	72.2	57.5	0.0001
Rearing types of livestock that are best adapted to the climate changes	60.9	67.9	71.8	66.9	0.0352
Selecting adaptive breeds among the existing	48.4	54.3	54.5	52.4	0.3061
keeping a variety of livestock especially the small ruminants	61.8	67.4	68	65.7	0.2891
Selling of livestock at the onset of drought to reduce on losses (Destocking)	44.5	46.8	55.3	48.8	0.0414
Diversifying into crop production activities	17.9	34.9	75.1	42.6	0.0001
Collection of livestock manure either for sale or decomposing for farm use	52.4	57.3	72.2	60.7	0.0001

Comparison of means based on Kruskal-Wallis rank sum test.

Table 5
Estimate of fractional and censored regression models of determinants of adaptive capacity.

	FRACTIONAL REGRESSION			CENSORED REGRESSION		
	Coefficients	std. err.	$p > z$	Coefficients	Std. err.	$p > t$
Risk taking	0.038**	0.010	0.000	−0.014**	0.003	0.000
Innovativeness	−0.016	0.013	0.202	−0.006	0.004	0.211
Proactiveness	0.033**	0.011	0.002	0.013**	0.004	0.002
Total CSA Adopted	0.019**	0.003	0.000	0.007**	0.001	0.000
Gender of household head	0.027	0.031	0.380	0.010	0.011	0.323
Age of household head	−0.001	0.001	0.468	0.000	0.000	0.415
Household Size	0.004	0.004	0.294	0.002	0.001	0.236
Education level of household head (Ref – Informal)						
Primary	0.069**	0.019	0.000	0.027**	0.007	0.000
Secondary	0.088**	0.023	0.000	0.035**	0.009	0.000
Tertiary	0.148**	0.028	0.000	0.058**	0.011	0.000
Marital status (Ref - married)						
Single	−0.063	0.040	0.116	−0.024	0.015	0.106
Widowed	0.008	0.037	0.821	0.004	0.013	0.783
Household main source of livelihood (Ref – Livestock farming)						
Other sources of livelihood	0.040*	0.019	0.032	0.016*	0.007	0.036
Household average Income	0.000**	0.000	0.000	0.000**	0.000	0.000
Extension Service Access	0.081**	0.016	0.000	0.032**	0.006	0.000
Participation in collective access	0.252**	0.018	0.000	0.098**	0.007	0.000
Access to Credit	0.141**	0.015	0.000	0.055**	0.006	0.000
Household L/S Production system (Ref - Agropastoralism)						
Pastoralism	−0.114**	0.022	0.000	−0.044**	0.008	0.000
Household's TLU	0.000	0.000	0.210	0.000	0.000	0.437
Years of Livestock farming experience	0.004**	0.001	0.000	0.002**	0.000	0.000
County (Ref- Kajiado)						
Taita Taveta	0.051*	0.023	0.024	0.020*	0.009	0.021
Laikipia	−0.074**	0.021	0.000	−0.029**	0.008	0.000
_cons	−0.486	0.057	0.000	0.312	0.021	0.000

*$p < 0.05$, **$p < 0.01$.

relationship between a higher number of CSA practices adoption and adaptive capacity demonstrates the need to strengthen mechanisms for scaling up the uptake of CSA in the pastoralist areas. This collaborates with the findings of Kifle [24] and Sardar [26] who posits that households that adopt more CSA practices have improve household welfare.

With regard to socioeconomic factors, age had a positive influence on adaptive capacity. Older farmers can leverage on experience to manage climatic change and the impact they have on their production [55]. Similarly, the age is associated with farming experiences which has a positive influence of the adoption of CSA practices [56]. However, some studies suggest that most youth are readily willing to adopt new farming technologies than older farmers hence age is negatively associated with the uptake of CSA [57–60]. Education level has a positive and significant influence on adaptive capacity. Farmers with higher education are assumed to have better cognition skills which influence decision making on the implementation of climate change adaptation strategies leading to improved adaptive capacity [18].

Household income had a significant and a positive effect on an adaptive capacity. Higher income provides resources for households adopt most of the CSA practices especially those that were capital intensive therefore increasing their adaptive capacity. These results collaborate those of Silvestri [5], Aryal [57] and Maindi [61]. Engaging in other sources of livelihoods apart from livestock is also positively associated with adaptive capacity. Having diverse sources of income acts as a cushion to the household in case their main source of income is greatly affected by the threats of climate change [31,35]. Pastoralism system production was found to be significant and negatively influencing adaptive capacity. Pastoralist households were more likely to have lower adaptive capacity index as opposed to those households were practicing agropastoralism. This could be explained by agropastoralism being one way of diversification and therefore increasing their AC a practice that many projects around the livestock based communities are promulgating [22,31].

Institutional factors such as access to extension services, membership in collective action and access to credit services positively influenced adaptive capacity. Access to extension service and increased the odds of a farmer adopting most of the CSA practices which enhances adaptive capacity. Through extension services, dissemination of information various CSA practices is increased [24,26,42,60,62–64]. Collective action broadens individuals' social networks and allows them to exchange and learn new information [18,22]. It also increases the farmers' ability to building savings as well as accessibility to loans which can be used to create wealth or start up small businesses hence increasing their adaptive capacity [18,36]. The findings further show a positive relationship between credit access and adaptive capacity. Credit can allow farmers to invest in technologies for minimizing impacts of climate changes [31, 55]. Some of the incentives that can help increase adaptive capacity would include providing market information, insurance services enhancing access to credit, markets and extension.

There is a great deal of uncertainties about the future of smallholder livestock farmers in the context of climate change, especially in the Arid and Semi-Arid Areas. Consequently, climate smart agricultural practices have been promoted among smallholder farmers to help support their adaptation to climate change. The sample used was a representative of the different agro-ecological zones, vulnerability levels and different livestock-based livelihood systems of the communities living in ASALs. Hence the results would inform interventions in a wider rangelands area. However, the results show some variations in the counties surveyed. This shows that there exist regional endogeneities which should be considered when designing interventions at the local level.

The paper has shown, as expected that uptake of livestock CSA practices is associated with a higher level of adaptive capacity. These results suggest the importance of promoting livestock specific CSAs such as livestock vaccination, use of veterinary services, rearing of adaptive breeds, diversification into crop production activities in enhancing livestock farmers adaptation to climate change. The paper has also shown that entrepreneurial orientation has mixed influence on livestock farmers adaptive capacity. While risk taking and proactiveness are positively associated with a higher adaptive capacity, innovativeness does not have an influence. These results point to the importance of considering the

individual constructs of EO – innovativeness, proactiveness, and risk-taking – when promoting entrepreneurial orientation of farmers. Hence entrepreneurship training and programmes dedicated to livestock farmers should not be designed as a one-size-fits-all activity, rather they should be tailored to influence the three dimensions of EO: risk-taking, innovativeness and proactiveness.

These results also suggest that the success of interventions to improve the adaptive capacity of smallholder livestock farmers within the livestock dependent communities is greatly anchored on change of mindset. Many farmers in SSA are risk averse and resistant to change (largely due to past failures and innovations that did not meet their expectations). This calls for EO mindset change as an entry point to initiate a transition from the cultural oriented farming systems to market-based systems which can improve the livelihoods of these communities. The other factors which positively influence adaptive capacity are demographic and socioeconomic characteristics of the household head (age, gender, education level, diversified income sources) and institutional characteristics (access to extension services, credit, and collective action). The findings suggest that a strategy to promote entrepreneurial orientation, uptake of CSA, accumulation of human and financial capital would enhance livestock producers' adaptive capacity.

The results provide evidence that cognitive factors are important drivers to improve adaptive capacity among the pastoralist communities. However, this study only considered EO characteristics. Future research should explore how the other cognitive factors such as perceptions and attitudes, can influence farmers decision towards climate change adaptation. Likewise, the results revealed that both EO and CSA adoption characteristics are important in enhancing adaptive capacity to climate change. However, there could also be possibility of a reverse causality where that adaptive capacity could influence the choice of livelihoods strategies which in turn determines the uptake of the CSA practices. Due to limitation of data this study did not analyze this effect even though it be relevant in informing policy on the CSA adoption. In addition, future research should examine how EO influence adoption of specific CSA practices. This will help to guide on the tailor-made policy interventions that can enhance CSA adoption. Moreover, our study used cross-sectional data, which cannot bring out the dynamics which are important especially in the climate change and variability context. For a better understanding of these dynamics, there is need to consider panel data which allows the study of farmers entrepreneurial characteristic evolution over time within the context of climate change.

Data availability statement

Data will be made available upon request.

CRediT authorship contribution statement

Evaline Chepng'etich: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Josiah Mwangi Ateka:** Writing – review & editing, Visualization, Supervision, Methodology, Formal analysis, Conceptualization. **Robert Mbeche:** Writing – review & editing, Visualization, Supervision, Methodology, Formal analysis, Conceptualization. **Forah Obebo:** Writing – review & editing, Visualization, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.csag.2024.100007.

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