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Determinants of coping strategies among agropastoralists in Kitui and Isiolo counties, Kenya

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Abstract
Agropastoralists in Kenya's Arid and Semi-arid Lands (ASALs) face various shocks that threaten their livelihoods and expose them to significant health and economic risks. While existing studies often focus on climate-related shocks, they frequently overlook other challenges faced by these communities. A comprehensive understanding of how agropastoralists manage diverse shocks is essential to developing effective vulnerability reduction strategies. This study examined the major shocks experienced by agropastoral households in Kenya's ASALs, their primary coping strategies, and the determinants informing the choice of the strategies adopted. Using cross-sectional data from 371 households in Isiolo (203) and Kitui (168) counties, this study applied descriptive analysis and multivariate probit (MVP) models to assess coping strategies and influencing factors. From 2016 to 2021, households faced shocks, such as droughts, livestock pests and diseases, crop pests, theft, and intercommunal conflicts. Regional variations were observed: crop pests were common in Kitui, whereas Isiolo experienced higher theft and conflict rates. Coping strategies include income diversification, asset sales, increased farm labor, and reduced food expenditure. Severe droughts and conflicts led to migration, while floods caused extreme measures such as withdrawing children from school. Key factors influencing coping strategies include household demographics, farm characteristics, and market proximity. Households with more adults, higher literacy, or greater income from crops and livestock are less likely to adopt costly strategies. This study recommends integrated interventions to enhance resilience to both climate and non-climate shocks.

Keywords Climate · Shocks · Copping strategies · Agropastoral · ASALs · Kenya

1 Introduction

Globally, the livelihoods of many poor rural populations, particularly those in arid and semiarid lands (ASALs), are increasingly threatened by a range of natural, economic, and social shocks. In this study, we define a shock as an event that results in severe and sudden disruption of normal socioeconomic activities, leading to widespread and long-lasting negative effects on ecosystems, economies, and human well-being. In ASALs, shocks adversely affect agro-pastoral communities in multifaceted ways, increasing their vulnerability to poverty and food insecurity. For instance, poor crop harvests and low livestock productivity are often attributed to climate-induced shocks such as severe droughts, erratic rainfall, and floods [1–3]. High inflation might result in difficulties in doing business, job loss, and high cost of living, which directly and indirectly affects livelihood sources.

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Although climate and non-climate shocks often impact households simultaneously [4, 5], necessitating that household heads concurrently address the resulting effects and associated challenges, much of the literature has studied the impact of shocks and coping strategies adapted in isolation. This approach might have great weaknesses since it fails to present a clear picture of how various households manage and cope with various shocks; for example, a household experiencing a single shock might use different coping strategies compared to a household managing multiple shocks. In addition, the factors influencing the choice of coping strategies might differ between households experiencing a single shock and those experiencing multiple shock. Although this methodological weakness was highlighted in a scoping review by Komarek [6], to date very few studies have documented how multiple shocks tend to affect households' vulnerability and the coping strategies they adopt. One such study was conducted in West Africa [7].

In Kenya, ASALs are home to many agropastoral communities; with twenty-three out of the forty-seven counties being classified as ASALs. Kenya's ASALs account for approximately 36% of the human population and 70% of the national domesticated livestock [8]. Similar to other global ASALs, these areas frequently experienced multiple shocks. Although empirical evidence shows that households in Kenya's ASALs are affected by various shocks that increase their vulnerability to poverty and food insecurity, no comprehensive study has examined the diverse coping strategies employed by these households to manage these shocks. Furthermore, although studies conducted in Kenya's ASALs tend to identify the strategies used by agropastoral communities to cope with shocks [9–11], they fail to determine the key drivers influencing the choice of *multiple* coping strategies. For instance, factors determine whether an individual will choose one strategy, a combination of strategies, or one strategy over another. In addition, most of these studies have focused on climatic shocks only, and they have studied them in silos [12, 13]. Anecdotal evidence exists on strategies agropastoral households in the ASALs of Kenya use to cope with the simultaneous occurrence of multiple shocks, and the determinants of the coping strategies selected/adapted, knowledge gaps this study aims to address. Understanding the drivers that influence the choice of coping strategies is essential for developing effective interventions and policies that support agropastoral practices in building resilience and enhancing adaptive capacity. Identifying and examining these drivers can shed light on the factors that shape decision-making processes among agropastoral communities in response to various shocks, and inform interventions to be designed or policy measures to be taken to build resilience among vulnerable groups.

2 Material and methods

2.1 Study area

This study was conducted in Kitui and Isiolo Counties, Kenya (Error! Reference source not found.**).** Isiolo County is located between longitudes 36°50 E' and 39°50' East and latitudes 0°05 south and 20° north, covering an area of 25,700 square kilometers. It has a total population of 268,002 people [14]. Most of the population depends on livestock keeping as the primary economic activity, with a few engaging in crop farming for subsistence. Kitui County is located between latitudes 0°10' South and 3°0' South and longitudes 37°50' East and 39°0' East, with altitudes ranging from 400 to 1800 m. It covers a total land area of 30,496 square kilometers with a total population of 1,136,187 people [14]. The majority of the population in Kitui County depend on both livestock and crop farming for their livelihood. These two counties are of great interest for this study because they are characterized by high poverty levels [14].

2.2 Study design and sampling techniques

This study applied a cross-sectional survey of agropastoral households in two counties. The sample size was determined using an unknown population sample size formula [15]. The formula is given in Eqs. 1 and 2:

$$n = \left(\frac{pqz^2}{\varepsilon^2}\right) \tag{1}$$

where:

n=sample size

p = proportion of interest; represents agropastoral households in the study area.

q=1-p

z=is the confidence level computed at 95% level.

ε is the error term (capturing the unobservable).
Therefore, p = 0.5; q = 1–0.5 = 0.5; z = 1.96; ε = 0.05; and

$$n = \left\{ \frac{\left(0.5 * 0.5 * \left[1.96^2\right]\right)}{0.05^2} \right\} = 384 \tag{2}$$

This study targeted 384 households, as computed in the formula above, but 13 of the questionnaires were incomplete and hence were not utilized at the analysis stage. Resulting to a sample size of 371 households.

A multistage sampling technique was used to identify the target respondents. In the first stage, based on proportion to size, 20 villages were randomly selected from each county. In the second stage, a list of eligible households per county from each of the selected villages was compiled with the support of local mobilizers, and this compiled list formed the sample frame. Households were randomly selected based on a proportional-to-size approach. Interviews were administered to household heads or spouses.

The household survey gathered comprehensive data on the demographic characteristics, sources of livelihood, and both the climate and non-climate shocks experienced by households between 2016 and 2021. It also includes information on access to essential resources and community facilities. Prior to data collection, the questionnaire was pre-tested to ensure appropriateness. The enumerators were trained before participating in the study. Data were collected in January and February 2022 using the Open Data Kit (ODK) platform.

2.3 Data analysis

Descriptive statistics, frequencies, and percentages were used to present the respondents' demographics and socioeconomic characteristics, major shocks, and coping strategies adopted by the sampled households. A Multivariate Probit (MVP) regression model was used to identify factors influencing the choice of coping strategies. The MVP model was the best-fit model because the study anticipated that households could use multiple strategies simultaneously to cope with shocks. The coping strategy chosen by a household was represented by a random variable (CS_i), which was assumed to be influenced by the household's social demographics, farm, and institutional characteristics. The MVP model was characterized by a set of binary dependent variables (CS_{ipm}), as shown in Eqs. 3 and 4.

$$CS^*_{ipm} = \beta^1_n X_{ipm} + \mu_{ipm} \ldots\ldots n = 1, \ldots\ldots, N \tag{3}$$

$$cs_{ipm} = \begin{cases} 1 \;\; if \; cs^*_{ipm} > 0 \\ 0 \;\; otherwise \end{cases} \tag{4}$$

where β^1_n is the corresponding vector parameter to be estimated and cs^*_{ipm} is the unobservable variable.

In Eq. 4, the study assumed that a rational household decision-maker has a latent variable cs^*_{ipm} that captures the unobservable preferences associated with the n^{th} choice of coping strategy from which he or she can choose. The latent variable was assumed to be a linear combination of household socioeconomic, asset endowment, and institutional characteristic (X_{ipm}) variables. These are observed to influence the simultaneous selection of coping strategies, as well as the unobserved characteristics captured by the stochastic error term μ_{ipm}.

The factors hypothesized to influence household heads' decisions to adopt certain strategies and the direction of influence are presented in Table 1. Data were analyzed using STATA software.

2.4 Research ethics

This research was approved by the Kenya National Commission for Science, Technology, and Innovation (NACOSTI) and Kenyatta University Research Committee. Considering that the data were collected during the heightened period of the COVID-19 pandemic, the data collection team adhered to COVID-19 protocols while conducting fieldwork activities. All study participants provided their informed consent.

Table 1 Variable used in MVP econometric model

Variable label	Variable definition	Expected effect
hh_headship	Gender of the household head (1 = male headed)	– or +
hh_age	Age of household head (years)	– or +
hh_educ	Education of the household head (school years)	– or +
dep_ratio	The number of household members under 14 and over 65 years who depend on economically active members (aged 15 to 65)	– or +
hh_size	Total number of people in the household	– or +
hh_primary_occupation	The primary source of income of the household head (1 = farming)	– or +
hh_member_agri_org	Membership to agricultural organization (1 = yes)	– or +
hh_land_size	Total land size under farming (hectares)	– or +
hh_annual_income	Annual income earned from non-farming economic activities (KES)	– or +
crop_income	Income generated from crop sales (KES)	– or +
livestock_income	Income generated from livestock sales (KES)	
dist_market	Distance to the nearest trading center or market (Kilometers)	– or +

"–" illustrates a negative influence, " + " illustrates a positive influence

3 Results

3.1 Descriptive statistics

Table 2 presents summary statistics of the sampled households. Of the total, 55% were from Isiolo County and 45% from Kitui County. Overall, 61% of the interviewed households were male headed. The average age of household heads was 44 years, with those in Kitui County being slightly older (45 years) compared to those in Isiolo (43 years). Similarly, the average age of their spouses was 37 years, with spouses in Kitui County being slightly older (39 years) compared to those in Isiolo (36 years). Overall, the interviewed households had an average of five members, with a dependency ratio of five. Households Kitui County exhibited a higher dependency ratio (five members) than Isiolo County households (four members). On average, households owned 3.16 hectares (ha) of land, with a significant ($p < 0.01$) statistical difference between Isiolo (1.728 ha) and Kitui (4.896 ha). The study also found a difference in access to leased land; 3 ha in Isiolo County compared to 0.93 ha for Kitui County.

Overall, and across the Counties, The sampled household heads exhibited a high level of illiteracy, with an average of seven years of formal education. This indicates that the majority had not completed primary school according to Kenya's formal education system. More than half of household heads rely on farming as their main source of livelihood, and a similar trend is observed across the two counties (Fig. 1).

The findings revealed low engagement in social activities among the sample respondents. Of the total, only 16% were active members of communal social groups. Membership in social groups varied by county ($p < 0.1$), with 18% of household heads in Isiolo County being members of social groups, compared to 14% of the households in Kitui County. Regarding access to infrastructure, households in Kitui were, on average, 4.48 km from the nearest market, compared to 2.50 km for the households in Isiolo County. The difference to the nearest market center was statistically significant ($p < 0.01$) when comparisons were made between households in Kitui and Isiolo County. Similarly, households in Isiolo County were 1.46 km from a paved road, while households in Kitui were 3.57 km away from the paved roads.

3.2 Major shocks reported to have occurred between 2016 and 2021

Figure 2 illustrates the shocks experienced by the respondents between 2016 and 2021. Severe drought emerged as the most frequently reported shock, affecting 96% of respondents. On average, the estimated annual losses per household due to drought were KES 203,656 for livestock and KES 45,067 for crops (Table 3). These results align with expectations given that the ASAL regions are highly susceptible to severe drought, leading to significant crop and livestock losses [16–18].

Table 2 Descriptive statistics of the sampled households

Variables	pooled		Kitui County		Isiolo County			
	Mean	S.D	Mean	S.D	Mean	S.D	t- test	Chi-square test
Household socio-economic characterizes								
Gender of HH (1 = male)	0.617	0.486	0.619	0.487	0.615	0.487		0.004
Age of the HH (years)	44.451	16.410	45.962	17.401	43.199	15.475	1.749*	
Marital status of the HH (1 = married)	0.806	0.396	0.786	0.412	0.823	0.383		0.802
Age of the spouse (years)	37.585	18.268	39.470	19.724	36.101	16.937	1.744*	
Education level of the spouse (schooling years)	6.481	4.654	6.830	4.356	6.208	4.869	1.262	
Primary occupation of HH (1 = crop and livestock farming)	0.601	0.490	0.613	0.488	0.591	0.492		0.184
Household size (number of household members)	4.851	2.019	4.369	1.907	5.251	2.027	−4.285***	
Dependency ratio (number of young and elderly people depending on economically active household members)	4.561	2.112	4.861	2.814	4.283	2.237	3.081***	
Household assets								
Owned land size (hectares)	3.162	0.152	4.896	0.220	1.728	0.149	−12.250***	
Leased land size (hectares)	1.232	0.312	3.000	2.000	0.938	0.138	−2.885**	
Total crop harvest (kgs)	430.167	21.183	621.458	29.069	271.857	25.495	−9.073***	
Institutional characteristics								
A member of agricultural organization (1 = yes)	0.164	0.371	0.142	0.351	0.182	0.387		1.039*
Distance to the nearest market (kilometers)	3.396	0.134	4.485	0.186	2.495	0.165	−8.031***	
Distance to the nearest paved road (kilometers)	2.414	0.125	3.567	0.196	1.459	0.126	−9.344***	

Significance levels; ***P < 0.01, ** P < 0.05 and * P < 0.1

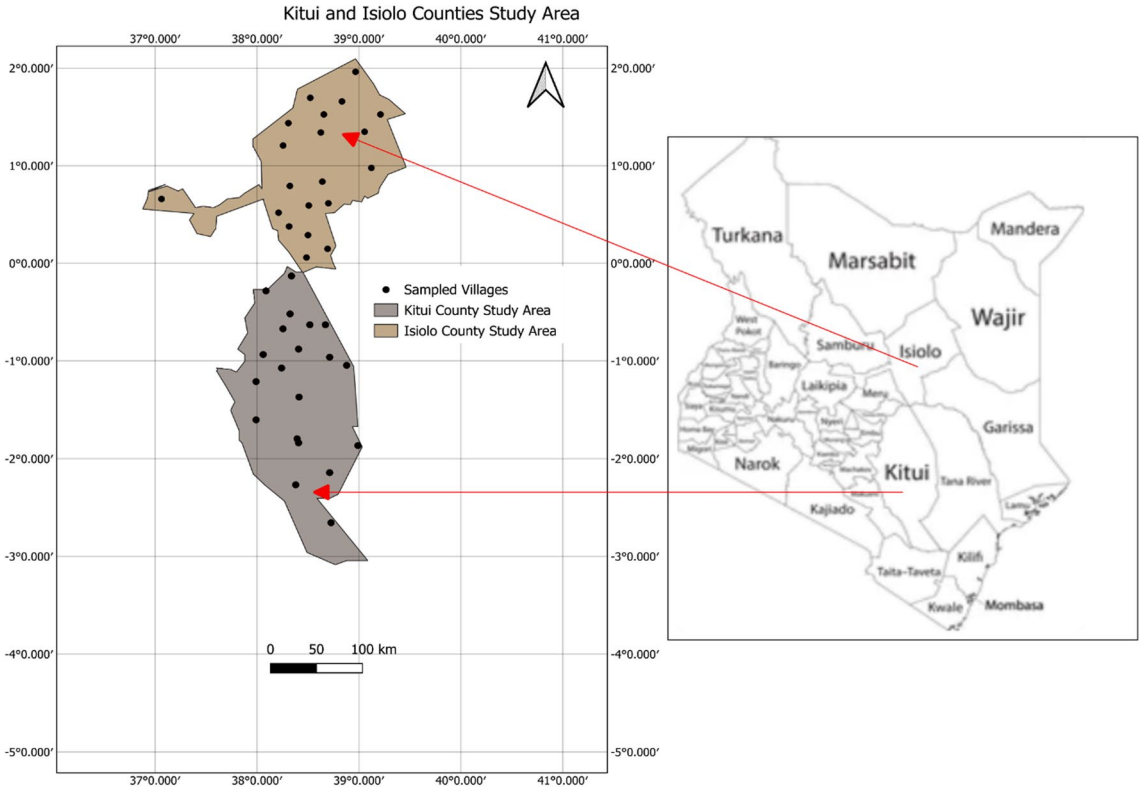

Fig. 1 Map of Isiolo and Kitui Counties, selected study area

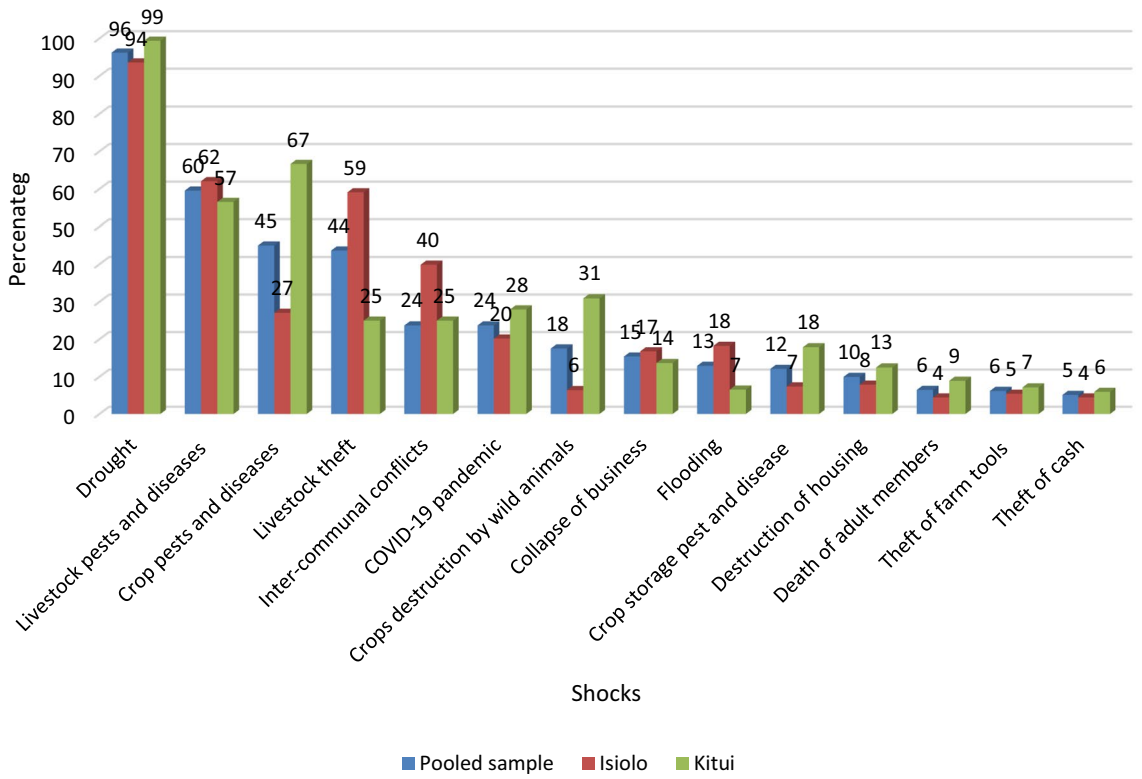

Fig. 2 Climate and non-climate shocks reported to have occurred between 2016 and 2021

Table 3 Losses due to climate and non-climate shocks

	Drought	Floods	Crop pest and diseases	Livestock pest and diseases	Livestock theft	Inter-communal conflicts	COVID-19
Livestock enterprise							
Mean	203,656.631	119,024.141	6,492.481	175,603.667	192,097.235	15,0957.322	19,678.932
SD	386,303.783	463,131.694	18,465.772	1159,630.812	344,675.891	317,002.031	51,486.881
Crop enterprise							
Mean	45,067.041	39,137.932	43,092.865	3,100.001	2,267.542	21,569.512	15,192.863
SD	177,599.591	105,248.256	102,242.981	20,503.331	11,707.001	49,824.590	36,386.351

Additionally, 60% of the respondents reported having been affected by livestock pests and diseases. The average annual household losses due to livestock pests and diseases were estimated at KES 175,603, with indirect crop losses (such as reduced manure availability) estimated at KES 3,100 per household (Table 3). These crop losses likely stem from the diversion of resources, where funds initially intended for purchasing seeds and fertilizers are redirected towards the treatment of livestock diseases and pest control.

A higher proportion of respondents (67%) in Kitui than in Isiolo (27%) reported to have been affected by crop pests and diseases. Similarly, more respondents in Kitui County (31%) than in Isiolo County (6%) reported destruction of field crops by wild animals. These findings are consistent with expectations because crop farming is a primary source of livelihood in Kitui, where many residents live near wildlife conservation areas. Furthermore, the drought-induced destruction of forest pastures can force wild animals to migrate to private ranches and crop fields. A similar situation was observed in a study in Malawi, where drought-related forest degradation pushed wildlife to rely on privately owned crop fields [16].

A larger proportion of respondents in Isiolo (59%) than in Kitui (25%) reported being affected by livestock theft between 2016 and 2021. The estimated average annual loss per household due to theft amounted to KES 192,097 (Table 3). This trend may be attributed to intercommunal conflicts, as more respondents in Isiolo (40%) than Kitui (25%) reported being affected by such conflicts. These conflicts are likely fueled by high poverty levels in Isiolo and exacerbated by climate change and limited resources, which may drive households to engage in cattle rustling.

An emerging shock reported by 24% of the respondents was the impact of the COVID-19 pandemic. Empirical evidence has shown that COVID-19 has heightened vulnerability to poverty and food insecurity, particularly in developing nations [19–21]. Other shocks reported by the respondents included the collapse of businesses (15%), destruction of houses (10%), theft of production tools/equipment (6%), death of an adult household member (6%), theft of cash (5%), loss of non-agricultural employment (3%), and loss of agricultural employment (1%).

These findings illustrate that agropastoral households in Kenya's ASALs face a variety of climate and non-climate shocks that threaten their livelihoods and increase their vulnerability to poverty in several ways. To better understand how households cope with these shocks, further analysis was conducted and the results are presented in the following section.

3.3 Strategies adapted by agropastoral households to cope with climate and non-climate shocks

Table 4 presents strategies employed by households to cope with shocks. Predominately adapted coping strategies for shocks triggered by drought are taking up an additional occupation (31%), selling livestock (23%), working harder, that is, putting more work and effort at the farm (23%), reduce household expenditure on food (15%), and use of savings (11%). These results collaborate with prior studies that have shown asset depletion, consumption smoothing, borrowing, income diversification, and migrating to other places to seek alternative sources of income as major coping strategies adopted to hedge against negative effects due to severe drought [9, 17, 22].

To hedge against the adverse effects of floods, most households report selling their assets (41%). This might indicate the immediate adverse effects caused by floods compared to drought, which forces the household to go for immediate income-generating options, such as the disposal of key household assets. Although such strategies might be of great benefit to cushioning households in the short term, they expose them to more vulnerability in the long run. Studies have shown that the disposal of household assets to hedge against shocks increases vulnerability to poverty and food insecurity [23–25]. Some household heads reported resorting to working harder (31%), taking up an additional income-generating occupation apart from farming (21%), and using saved income (10%) to cushion their families against shocks caused by floods. These findings corroborate those of [26].

Table 4 Strategies adapted by agropastoral households to cope with climate and non-climate shocks

Coping strategies	Drought (%)	Floods	Crop pests and diseases	Livestock pests and diseases	Livestock theft	Inter-communal conflicts	COVID-19 pandemic
Took up additional occupation	**30.702**	**20.691**	**26.322**	**18.826**	**25.221**	**12.201**	**30.362**
Sold livestock |	**22.544**	3.456	**17.292**	**25.887**	**13.042**	**18.292**	**12.501**
Work harder	**23.101**	**31.031**	**23.313**	**22.354**	**24.351**	**18.292**	**23.217**
Reduced consumption (food expenditure)	**14.631**	6.902	9.777	3.533	3.481	2.441	3.573
Household migrated in search of job	8.735	3.451	6.771	4.121	2.614	**18.292**	0.000
De-save	**11.271**	**10.348**	**16.542**	**17.061**	12.171	9.765	**14.291**
Sold assets	2.547	**41.382**	0.750	4.713	2.610	7.324	7.142
Took children out of school	1.412	**10.352**	1.501	1.181	0.870	3.663	1.791
Sold land	0.001	**13.791**	1.502	0.000	0.870	1.221	0.000
Sold crops	1.134	0.000	2.261	1.761	0.870	1.221	7.142
Formal insurance	0.562	3.452	0.751	0.000	0.870	0.000	0.000
Borrow money from lender	2.541	3.451	0.000	1.761	2.614	1.221	1.791
Borrow money from relatives	5.632	0.000	9.771	5.881	4.351	2.443	3.573
Borrow money from non-relatives	4.511	6.901	6.772	1.761	3.482	2.443	0.000
Gift from relatives and non-relatives	3.661	3.458	6.772	0.591	3.482	1.221	1.791
Financial support from government	2.794	3.452	3.011	4.121	**18.261**	9.765	1.791
Financial support from NGOs and religious groups	3.142	8.621	3.011	1.761	0.871	6.101	7.142
Number of observations	355	29	133	170	115	82	56

Bold values indicate the most reported coping strategies

Unlike droughts, where most households (22%) reported selling livestock for floods, only a few households (3%) reported depending on the sale of livestock. This suggests that although floods affect household assets, there is plenty of pasture to feed cattle; hence, the agropastoral community tends to hold on to cattle. Some households (10%) decided to stop their children from attending school during the flooding period. This is expected because most school infrastructure is destroyed by floods, and most roads are impassible. Studies have shown that fundamental coping strategies during flooding include using child labor, selling household assets, borrowing money, and migrating to safer grounds [27–29]. Although a study in India showed that households prone to floods prefer to relocate properties temporarily or human beings to safer areas [30], in this study, only a few (3%) of respondents reported migrating in case of floods. This could be due to the Kenyan land ownership policy, which makes it difficult for vulnerable households to encroach on private property.

The occurrence of crop pests and diseases forced most households to take up an additional occupation to boost their household income (26%), work harder (23%), and use the saved income (17%). Seventeen percent of households depend on the sale of household livestock to hedge against adverse effects of crop pests and diseases. This being agropastoral community, these results were expected since in absence of alternative source of income, the household might tend to dispose some of their animals and use the income on household expenditure, farm inputs such as pesticides and animal drugs.

Coping strategies adopted by households to manage livestock pests and diseases included taking up an additional occupation (19%), selling livestock (26%), working harder (22%), and de-saving (17%). For livestock theft, households employed strategies such as taking up an additional occupation (25%), working harder (24%), selling livestock (13%), and obtaining financial support from the government (18%). The fear of losing animals to disease or theft may have compelled livestock keepers to dispose of a fraction of their herds. This unplanned disposal can increase vulnerability to poverty and food insecurity.

Strategies adopted by the sampled households during intercommunal conflicts included selling livestock (18%), working harder (18%), migrating household members in search of better-paying jobs (18%), and taking up an additional occupation (12%). Migration to a secure place was expected because intercommunal conflicts increase insecurity and, in most cases, household heads find it difficult to engage in income-generating activities. Although households complained about crop field destruction by wild animals, they did not take any action to address this issue. None of the households reported having developed better coping strategies to protect themselves from wild animals.

The Covid-10 pandemic has had a profound impact on global economies, with rural communities, particularly those dependent on agriculture and livestock, being vulnerable [31]. Households in Kitui and Isiolo Counties opted for strategies such as taking up additional occupations, selling livestock, working harder on the farm, and de-saving. This is consistent with previous studies [32, 33]

3.4 Factors influencing the choice of coping strategies

Table 5 presents results on factors influencing the choice of coping strategies adapted by household. The MVP model results indicate a good fit, as shown by significant Wald Chi^2. This implies that the model has good explanatory power on factors influencing the choice of household coping strategies. The study starts by presenting findings on coping strategies adapted against drought. Drought had a positive and significant coefficient on household reduction in food consumption ($p < 0.01$), use of saving ($p < 0.05$), and sale of household assets ($p < 0.05$). These results imply that occurrence of severe drought tends to increase the probability of household reducing expenditure on food consumption, de-saving, and selling household assets. Major shocks resulting from severe droughts include destruction of pasture, crops, and high animal mortality; hence this increases vulnerability to food insecurity and poverty. Hence as a coping strategy household heads might tend to use less money on food by mainly consuming staple foods which are affordable, in extreme cases the households might decide to reduce the number of meals they take in a day. In extreme cases the household heads might decide to de-save or sell some of the valuable household assets and channel the money to household basic needs. These findings conform with those reported by [25, 34].

Severe floods had a significant positive correlation with household reduction in food consumption expenditure ($p < 0.1$) and the use of savings ($p < 0.1$). These findings suggest that the occurrence of severe floods increases the probability of households cutting household food expenditures and using the resources saved during the difficulties resulting from the destruction caused by floods. Floods are known to result in the destruction of crop fields, and in some cases, swipe away animals and other household assets. In some instances, severe floods tend to destroy housing structures, rendering the affected households homeless. Similar findings have been reported previously [35–37].

Table 5 Factors influencing the choice of coping strategies

Variables	Reduce consumption		Migrate		Use savings		Sell assets		Income diversification	
	Coef	Std. err	Coef	Std. err	Coef	Std. err	Coef	Std. err	Coef	Std err
Climate related shocks										
Severe drought (1 = yes)	0.175***	0.120	0.151	0.143	0.135**	0.126	0.182**	0.102	0.069	0.092
Severe floods (1 = yes)	0.266*	0.077	0.116	0.072	0.107*	0.072	0.024	0.053	−0.006	0.048
Non-climate shocks										
crop pest and diseases (1 = yes_	0.009*	0.022	0.000	0.024	0.001	0.021	0.015	0.018	0.006	0.016
livestock pest and diseases (1 = yes)	0.018**	0.035	0.015	0.034	0.046	0.035	0.050	0.031	0.007	0.023
COVID-19 pandemic (1 = yes)	0.288***	0.022	0.379	0.366	0.030**	0.199	−0.141	0.255	−0.710*	0.197
Intercommunal conflicts (1 = yes)	0.215*	0.275	0.011*	0.472	0.271	0.257	−0.263	0.433	−0.030	0.201
Household' characteristics										
Household headship (1 = male headed)	0.351*	0.211	0.119	0.228	0.103	0.189	0.073	0.163	0.152	0.146
Marital status of the household head (1 = married)	−0.643***	0.237	0.016	0.286	0.517*	0.259	−0.253	0.198	0.027	0.181
Age of the household head (years)	0.002	0.008	−0.013	0.009	−0.008	0.008	0.004	0.006	0.002	0.006

Table 5 (continued)

Variables	Reduce consumption		Migrate		Use savings		Sell assets		Income diversification	
	Coef	Std. err	Coef	Std. err	Coef	Std. err	Coef	Std. err	Coef	Std err
Education of the household head (years)	−0.043*	0.021	−0.020	0.024	0.016	0.021	−0.026	0.018	0.016	0.016
Dependency ratio	−0.014	0.355	−0.375	0.355	0.455	0.356	0.175	0.261	0.447*	0.248
Number of the adults	0.058	0.147	0.243*	0.138	−0.216	0.151	0.141	0.105	0.168*	0.101
Primary occupation of the household head (1 = crop and livestock farming)	−0.200	0.195	0.056	0.215	0.604***	0.183	0.112	0.154	0.002	0.138
Household head a member of agricultural association (1 = yes)	0.225	0.259	−0.132	0.333	0.170	0.248	0.038	0.215	0.059	0.189
Household assets and resource endowment										
Land size owned by the household (ha)	0.003	0.017	−0.011	0.023	0.002	0.012	0.018	0.011	−0.012	0.010
Annual household income from farming (log)	−0.073***	0.020	0.025	0.024	0.020	0.020	0.015	0.017	0.041***	0.015
Institutional factors										

Table 5 (continued)

Variables	Reduce consumption		Migrate		Use savings		Sell assets		Income diversification	
	Coef	Std. err	Coef	Std. err	Coef	Std. err	Coef	Std. err	Coef	Std err
Distance to the market (walking time in minutes)	−0.011	0.011	0.005	0.007	0.001	0.007	−0.018**	0.008	−0.016***	0.006
Constant	0.010	0.625	0.119	0.228	−0.943	0.623	−1.377	0.549	−0.803	0.451
Number of observations	371.000									
log likelihood value	−629.103									
Wald $chi^2(60)$	69.600*									
Likelihood ratio test	rho21 = rho31 = rho41 = rho51 = rho61 = rho32 = rho42 = rho52 = rho62 = rho43 = rho53 = rho63 = rho54 = rho64 = rho65 = 0: chi2(15) = 31.5099 Prob > chi2 = 0.007									

Significance levels; ***P < 0.01, ** P < 0.05 and * P < 0.1

Regarding non-climate shocks, livestock and crop pests and diseases had a positive and significant coefficient on household reduction in consumption expenditure. These results suggest that households tend to spend less on household food when their livestock, crops, or both are affected by diseases or pests. This could be because most of the population depends on livestock and crops as primary sources of income; hence, destruction due to pests and diseases directly affects their livelihoods. In addition, in the event of pest or disease outbreaks, households may be compelled to channel large amounts of household income to purchase pests and drugs. This could translate directly into a reduction in income supposed to purchase household food. A report by the Food and Agricultural Organization of the United Nations reported that the occurrence of livestock pests directly affects household livelihood due to the death of livestock, and most households tend to be affected more during outbreaks of livestock diseases because they redirect most of their income towards pest and disease management [38].

The COVID-19 pandemic had a positive and significant coefficient with regard to household reduction in consumption ($p < 0.01$) and use of savings ($p < 0.05$) and a negative and weak significant coefficient ($p < 0.1$) with income diversification. These results suggest that the COVID-19 pandemic increased the probability of household heads reducing household expenditures, such as money spent on food, and some used household savings to cushion themselves against the adverse effects of the COVID-19 pandemic. Studies have shown that the COVID-19 containment measures imposed by most governments have made many people lose their livelihoods; the majority have lost their jobs, and others have been forced to shut down their businesses [39–41]. In addition, lockdowns could have affected the movement of breadwinners, making it difficult for them to engage in non-farm economic activities.

Intercommunal conflicts had a positive and significant coefficient on household reduction in consumption ($p < 0.1$) and migration of household members from flood-affected regions ($p < 0.1$). Intercommunal conflicts usually result in the destruction of livelihood sources, such as food and even theft or death of domestic animals, which might compel household heads to cut on household expenditure due to fear of uncertainties. Flooding also tends to destroy housing structures, forcing households to move to safer places for fear of being swiped by floods or landslides. Similar findings were reported in the FAO report [42].

Household headship had a positive and a weak significant coefficient ($p < 0.1$) with a reduction in household food consumption expenditure. This result implies that the probability of male-headed households opting to cut household food expenditure during difficult times was very high compared to female-headed households. These results are quite intriguing considering that in most local setups of developing nations, female-headed households are resource-constrained compared to male-headed households; hence, we anticipated that they would cut on household expenditure compared to their male counterparts. Empirical evidence has shown that women tend to allocate most of their income and savings to household needs [43]; hence, women not cutting on household expenditure could hold during a shorter period, as they would strive to use their limited resources and savings to ensure that their household members are well-fed during difficult times. However, this aspect requires further exploration through qualitative research methods that can help to identify the reasons.

Additionally, household marital status had a negative and strong significance ($p < 0.01$) coefficient with a reduction in food consumption and a positive but weak significant ($p < 0.1$) coefficient on the use of savings as a coping strategy against shocks. This implies that households with both couples can join efforts to source adequate food for consumption by household members, unlike female-headed households, which may struggle to multitask between handling domestic chores and engaging in economic activities. Households headed by a collaborative couple, owing to their joint efforts, are able to generate more income that they allocate to immediate needs and save part of it. This is unlike female-headed households, where the head has a huge responsibility to take care of the entire household single-handedly, which may result in an inability to earn extra income for saving [44]. Equally, the likelihood of falling into non-saving decreases as one gets married because there are more laborers in the family.

The highest level of education attained by the household heads had a negative and weak significance ($p < 0.1$), with a reduction in household consumption expenditure in the event of shocks. This could be due to the learned household heads' understanding of the importance of household nutrition and general food security. Hence, instead of compromising household food security, they used other methods to cushion their household members during difficulties. Similar findings were reported by [45], who found that educated household heads were less likely to adapt to reduced household consumption because they understood that reducing household consumption expenditure during difficult times could result in poor health conditions among household members, particularly among young children.

The household dependency ratio has a positive and weak significant coefficient ($p < 0.1$) with household income diversification. This implies that the higher the number of non-working household members, the higher the pressure on working household members to generate income to support dependent household members. Therefore, the household

will opt to explore additional income (nonagricultural) to sustainably provide household members. The number of adult members in the household has a positive and significant coefficient on household member migration ($p < 0.1$) and income diversification ($p < 0.1$). This finding implies that it is more convenient for households with adult members to migrate to other places, particularly to engage in better income-generating activities. Similar findings were reported by [25], who indicated a significant positive association between the ratio of adult household members to migration to urban centers to seek better income.

The household head's primary occupation had a positive and strong significance ($p < 0.01$) coefficient regarding the use of savings as a coping strategy. These results imply that households that depend only on farming as their main source of livelihood are more prone to shocks affecting crop and livestock production. Hence, in most cases, they use their savings to cushion their family. Additionally, annual household income has a negative and significant coefficient regarding the reduction in food consumption as a strategy against shock(s). This might be because households with a high annual income can afford sufficient food for household consumption; thus, reducing food consumption becomes a less likely strategy to use against shock. Household distance to the nearest trading center had a negative and significant coefficient with the sale of assets ($p < 0.05$) and diversification of household income (non-farm) ($p < 0.01$). This implies that households far away from the trading center have limited access to the market and opportunities for the sale of their assets or income diversification (non-farm).

4 Conclusion and recommendations

This study sought to identify the major shocks experienced by agropastoral households in Kitui and Isiolo Counties, as well as the key coping strategies adopted by these households. The findings indicate that climatic shocks, primarily droughts and floods, have a significant impact on households, leading to widespread loss of livestock and crops, which are their primary sources of livelihood. Non-climatic shocks, including livestock and crop pests and diseases, livestock theft, pandemics, community conflicts, and crop destruction by wildlife also pose substantial challenges.

In response, households have employed various coping and adaptive strategies. These include costly measures such as selling assets, diversifying income sources, and reducing consumption. The study revealed that factors such as the gender of the household head, the education level of the household head and spouse, household resource endowment, and annual income played critical roles in shaping these strategies.

The shocks not only affected household food consumption patterns but also forced the sale of essential assets, thereby exacerbating their vulnerability. For instance, livestock pests and diseases have led to increased household expenditure on treatment, which has strained their resources. This study emphasizes the need for targeted interventions such as vaccination programs to alleviate the burden of livestock diseases and pests. Additionally, enhancing crop productivity through irrigation and adopting high-yielding varieties can improve food security and reduce the need to liquidate assets or disrupt consumption patterns.

Further, there is a pressing need to equip smallholder farmers with educational and entrepreneurial skills to diversify their income streams through alternative economic activities such as small business operations. Improving infrastructure, particularly road networks, would enable farmers to access market opportunities more efficiently.

The study underscores that most households employed coping strategies to manage a range of risks, with some respondents reporting inaction when faced with wildlife-induced destruction of crops and livestock. This highlights the urgent need for appropriate interventions to address wildlife-related shocks that severely impact agropastoralists' livelihoods. Additionally, strengthening business and entrepreneurial skills among vulnerable individuals is crucial to income diversification.

Given the cross-sectional nature of this study, future research should incorporate time-series data to better understand the frequency, impact, and evolution of these shocks, as well as household coping mechanisms over time. A qualitative approach also provides deeper insights into the challenges and motivations behind the choice of coping strategies, offering a more comprehensive understanding of households' responses to shocks.

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Data availability The data that support the findings of this study are available from the authors upon request.

Declarations

Competing interests The authors declare no competing interests.

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