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Pastoral vulnerability to drought: geographic and socio-demographic drivers of drought-related camel mortality in Somalia

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Pastoralism supports over 60% of Somalia's population, with camels being vital for economic resilience. However, intensifying droughts pose severe threats. This study addresses the gap in species-specific data by identifying geographic and socio-demographic drivers of household-level camel mortality in Somalia. Using the 2020 Somalia Demographic and Health Survey, we analyzed 5,925 camel-owning households. The outcome was self-reported camel death due to drought within the preceding 12 months. Multivariable logistic regression identified independent predictors, controlling for socio-demographic, economic, and environmental confounders. Overall drought-related camel mortality was 45.91%. Geographic location was the dominant predictor; compared to Awdal, risk was highest in Sool (AOR = 7.74; 95% CI 5.76–10.41, $p < 0.001$), Nugaal (AOR = 4.12; 95% CI 2.93–5.80, $p < 0.001$), and Sanaag (AOR = 4.07; 95% CI 3.02–5.49, $p < 0.001$). Nomadic households faced significantly higher odds of loss than urban households (AOR = 2.87; 95% CI 2.29–3.60, $p < 0.001$). Additionally, susceptibility increased with the age of the household head, particularly for those over 54 years (AOR = 1.59; 95% CI 1.31–1.92, $p < 0.001$). Wealth index and household head sex were not statistically significant in the adjusted model. Camel mortality is driven by systemic and geographic vulnerabilities rather than individual economic status, highlighting the failure of traditional coping mechanisms against community-wide shocks. Resilience strategies must shift from reactive aid to proactive measures, including culturally adapted Index-Based Livestock Insurance (IBLI), community-based recovery systems like camel leasing, and strengthened market infrastructure.

KEYWORDS
camel mortality, climate change, drought, pastoralism, resilience

Introduction

Pastoralism is a traditional livelihood integral to the socio-economic structure of arid and semi-arid lands (ASALs), primarily focusing on the raising of livestock, including camels, goats, sheep, and cattle. It provides a foundation for subsistence, income, and cultural identity for millions globally, notably in the Horn of Africa (Faraz et al., 2021; Thornton et al., 2024). This method is distinguished by its adaptable mobility, which allows herders to follow seasonal pastures and water sources—a tactic honed over millennia to

thrive in uncertain conditions. The ultimate purpose of researching pastoral susceptibility to drought, with a particular emphasis on camel mortality, is to identify crucial elements that either increase or reduce these effects, allowing for more effective adaptation techniques and governmental interventions (Menghistu et al., 2020). The resilience of pastoralist communities, whose livelihoods are inevitably linked to healthy livestock, is constantly threatened by the increasing severity and frequency of drought events brought on by climate change. This poses an existential threat that results in significant livestock losses, diminished livelihoods, and increased vulnerability, making this research crucial (Tofu, 2024).

Historically, arid and semi-arid regions globally have always struggled with climate change. However, the frequency and severity of drought episodes have significantly increased in recent decades, pushing a large portion of food production outside safe climatic spaces (Kummu et al., 2021). This global problem emerges as intense heatwaves, floods, and especially severe droughts, which have a considerable impact on pastoralist livelihoods (Parkes et al., 2022). On the African continent, particularly the Horn of Africa, drought has been a common occurrence that has influenced societal structures, migration patterns, and the economy. However, recent drought events have been exceptional in their intensity, resulting in massive displacement, food insecurity, and humanitarian crises (Shibru et al., 2023). Somalia, a country already dealing with decades of conflict and instability, has faced repetitive climate-related shocks and natural disasters that necessitate learning from historical patterns to build future resilience (Coly et al., 2023). Since 1991, temperatures in the region have risen steadily, with projections indicating a continued increase in climate extremes and a shift in agro-climatic zones by the end of the century (Demissie et al., 2025). Studies of pastoral resilience and livestock mortality are especially important since these climate changes intensify pre-existing vulnerabilities.

Somalia highlights the important link between pastoralism and climate vulnerability, where livestock management remains a primary strategy for navigating environmental stress (Awale, 2024). Since livestock production is a cornerstone of the national economy, its stability is closely linked to the wellbeing of pastoral systems. In Somalia, the agrarian and pastoral context is deeply intertwined with harsh ecological realities. Livelihood activities span a continuum from purely nomadic herding to localized agro-pastoralism. Nomadic herders rely exclusively on extensive, communal rangelands, navigating complex social networks to access ephemeral water points and grazing lands. Conversely, agro-pastoralists and urban-adjacent herders integrate livestock rearing with opportunistic crop cultivation or market trading. Camels are crucial assets and symbols of prosperity and resilience for pastoralists because they are so well suited to the harsh, dry circumstances of this area; indeed, a shift toward camel and goat farming is often seen as a necessary adaptation to sustain milk production under lower inputs and higher emissions (Rahimi et al., 2022). They provide milk, meat, revenue, and essential transportation, yet their future distribution is threatened by shifting habitats due to climate change (Abrhaley and Tesfay, 2025).

Despite their well-recognized adaptation to arid environments, camels remain vulnerable to a range of health and management challenges that can contribute to mortality, particularly during prolonged droughts. Previous studies conducted in pastoral camel production systems in the Horn of Africa, particularly the Somali Region of Ethiopia, have identified camelpox, contagious ecthyma, respiratory diseases, tick infestations, mange, and calf diarrheal diseases as major health constraints affecting camel survival and productivity (Hussein et al., 2024). Drought conditions can exacerbate these challenges by reducing feed and water availability, weakening animal immunity, increasing physiological stress, and heightening susceptibility to infectious and parasitic diseases. High camel calf mortality has been reported as a major constraint to herd growth and pastoral livelihoods, highlighting the interaction between environmental stressors, disease burden, and husbandry practices (Hussein et al., 2024). Furthermore, recent evidence from Somaliland demonstrated that camel mortality is shaped not only by climatic factors but also by socio-demographic and environmental conditions, emphasizing the need for a comprehensive understanding of mortality drivers in Somali pastoral communities (Hassan and Salih, 2026).

The recurring droughts in East Africa have led to enormous losses, with human-induced climate change significantly increasing the severity of recent drought events (Kimutai et al., 2025). Despite their well-known resilience, even camels are giving in to harsher circumstances, underscoring an essential research gap: while earlier research has touched on general livestock susceptibility, nationally representative evidence on drought-related camel mortality and its determinants across Somalia remains limited (North et al., 2026). It is important to close this gap in order to design focused policies that can strengthen Somali pastoralists' ability to adjust to future climate shocks.

In this study, drought-related camel mortality is conceptualized not merely as the biological consequence of acute water scarcity, but as a complex outcome driven by cascading socio-ecological failures. Direct causal factors include starvation due to rangeland depletion and dehydration from the drying of surface water. Indirect causal factors include disease outbreaks, heat stress, and the exhaustion of physical reserves during extended migrations. Furthermore, systemic constraints, such as restricted access to traditional pastures, localized resource-based conflicts, and delays in emergency relief programs, act as critical catalysts that transform a severe climatic hazard into a fatal event for livestock.

Previous studies have frequently given a general picture of how drought affects pastoral livelihoods, but they have seldom examined the precise, complex determinants influencing species-specific mortality at a granular level across a variety of geographic and socioeconomic situations (Cho et al., 2025). This absence is especially significant for camels in Somalia, given their importance to the economy and culture. While generalized vulnerability assessments exist, there is a need to track adaptation from both governmental and livestock keeper perspectives to ensure policies are grounded in local realities (Njuguna et al., 2024). This study addresses this gap by using data from the 2020 Somalia Demographic and Health Survey (SDHS), a nationally representative, high-quality dataset. This study goes beyond broad trends by assessing socio-demographic and economic characteristics, as well as self-reported camel death, to determine the particular risk factors that lead to camel loss at the household

level. The main objectives are to determine the national prevalence and regional patterns of camel mortality due to drought, identify associated socioeconomic drivers, and provide evidence-based insights to inform policies that improve the resilience of Somali pastoralist communities.

Materials and methods

Study setting

The study was conducted in Somalia, a country in the Horn of Africa. The country's geography is dominated by dry and semi-arid regions, rendering it highly vulnerable to repeated droughts and climate shocks. An estimated 60% of the population engages in pastoralism or agro-pastoralism, making livestock production, notably of camels, goats, and sheep, vital to the national economy and household food security (Catley et al., 2016).

The temporal context of this study capturing mortality in the 12 months preceding the 2020 SDHS is critical to understanding the underlying climatic drivers. This period coincided with severe, spatially uneven climate anomalies across Somalia. Following a series of historically erratic rainy seasons, the late 2019 *Deyr* (short rains) and the 2020 *Gu* (long rains) were marked by poor distribution and significant moisture deficits in the northern and central regions. Specifically, historical climate tracking during this period reveals that regions such as Sool, Sanaag, Nugaal, and Mudug experienced intense, prolonged dry spells that decimated primary pastures. In contrast, southern regions such as Gedo and Lower Juba received relatively better, albeit still erratic, rainfall and benefited from riverine microclimates along the Juba and Shabelle rivers, offering alternative grazing and water buffers.

Data source and sampling

This study used data from the 2020 Somalia Demographic and Health Survey (SDHS), which is a nationally representative cross-sectional survey. The SDHS was implemented by the Somali National Bureau of Statistics with technical assistance from ICF's DHS Program. The survey used a two-stage stratified sampling design. In the first stage, 556 enumeration areas (EAs) were selected with a probability proportional to their size. In the second stage, a set number of 28 households were methodically chosen from each EA. This study focused on the household-level dataset, with the analysis limited to homes that reported owning camels. From the total number of households questioned, a final sample of 5,925 households met the inclusion requirements for this study.

Variables

Dependent variable

The outcome variable was camel mortality caused by drought. This binary variable was obtained from the household questionnaire and was only administered to households that had previously reported losing camels. These households were asked if they had lost any camels due to drought in the previous 12 months. Responses were categorized as "1" if the household reported such losses (Yes) and "0" otherwise (No).

Independent variables

The selection of independent variables was guided by the availability of relevant indicators within the 2020 SDHS dataset (SHDS, 2020). These variables covered three domains. Socio-demographic factors included the region of residence (16 administrative regions), type of residence (urban, rural, or nomadic), gender of the household head (male or female), age of the household head (categorized as <30, 30–40, 41–54, and >54 years), and household size (categorized as 1–4, 5–8, or 9+ members). Economic indicators included the DHS Wealth Index (poor, middle, and rich), as well as a binary variable for asset ownership, which was created by combining ownership of the following items: mobile phone, watch, donkey cart, boat or canoe, computer, tractor, rickshaw, animal plough, and internet access. Finally, household and environmental conditions were represented by proxies for access to basic infrastructure: source of drinking water and type of toilet facility, both of which were recoded as improved or unimproved.

Statistical analysis

All data were cleaned, managed, and analyzed with Stata 16.0. The statistical analysis was carried out in two stages to ensure a thorough review of the data.

Descriptive analysis

Descriptive statistics, such as frequencies and percentages, were used to characterize the socio-demographic, economic, and environmental aspects of the 5,925 households in the study. This stage also includes determining the overall prevalence of drought-related camel death.

Multivariable analysis

A multivariate logistic regression model was developed to identify independent predictors of drought-related camel mortality while controlling for the effects of other variables. This model is suitable for a binary dependent variable. The results were provided as Crude Odds Ratios (COR) from the bivariate analyses and Adjusted Odds Ratios (AOR) from the multivariable model, as well as their respective 95% confidence intervals (CI). A diagnostic test for multicollinearity using the Variance Inflation Factor (VIF) was done before to finalizing the model. A VIF score of less than 10 is a widely accepted threshold that indicates that the variance of the regression coefficients is not unnecessarily inflated by correlations among the predictors.

Ethical considerations

This study is based on an analysis of publicly available, anonymized secondary data from The DHS Program. The initial

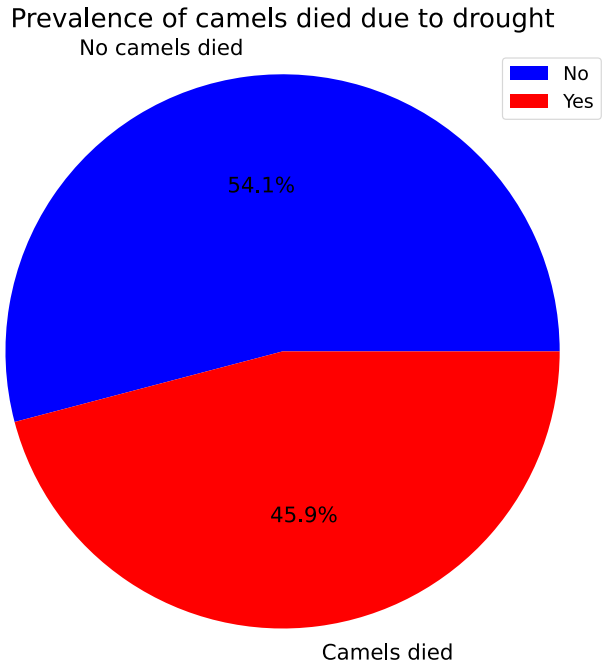

FIGURE 1
Prevalence of camels died due to drought.

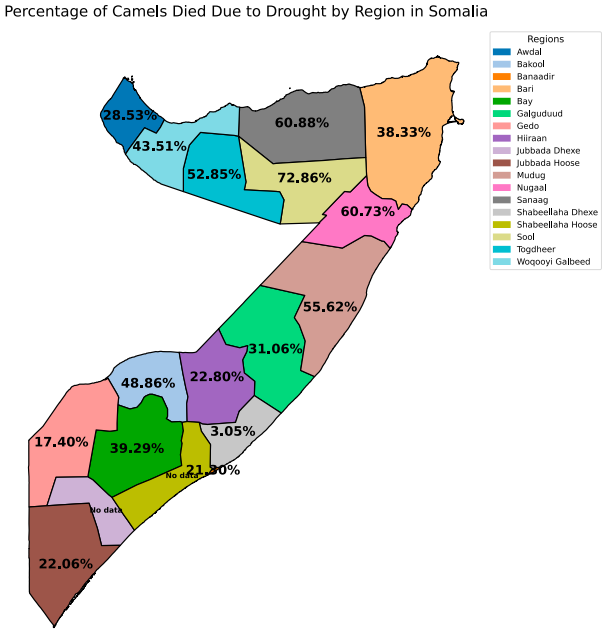

FIGURE 2
Percentage of Camels died due to drought by Region in Somalia.

version of the 2020 SDHS protocol was evaluated and approved by ICF's Institutional Review Board in Rockville, Maryland, and the Somali National Bureau of Statistics. The first data collection teams acquired informed consent from each and every participant. To maintain respondent confidentiality, all personal identities were deleted from the dataset before public release, so no additional ethical approval was necessary for this secondary study.

Results

Prevalence and geographic variation of camel mortality

The overall prevalence of camel mortality from drought reported by pastoral households was 45.91% (Figure 1). Significant spatial variance was seen throughout Somalia (Figure 2). The reported fatality rates ranged significantly, with Sool having the highest frequency (72.86%), followed by Sanaag (60.88%), Nugaal (60.73%), and Mudug (55.62%). Middle Shabelle had the lowest rates of camel mortality (3.05%), followed by Gedo (17.40%), Banadir (21.30%), and Hiraan (22.80%).

Socio-demographic characteristics of pastoral households

A total of 5,925 pastoral households were included in this study. The socio-demographic profile highlights the difficult situations that these populations are facing (Table 1). The majority of households (55.71%) were classified as nomadic, with lesser proportions living in rural (28.44%) and urban (15.85%) settings. The majority of households were headed by men (66.67%). The vulnerability of the economy was high, with the vast majority of households (80.84%) falling into the poor wealth category. Living conditions were poor, as indicated by the high frequency of inadequate sanitation (81.28%) and unimproved water sources (56.68%).

Multicollinearity diagnostics

Before starting the multivariable analysis, the Variance Inflation Factor (VIF) was used to examine the possibility of multicollinearity (Table 2). All individual VIF values were low, ranging from 1.02 to 1.62, and the mean VIF was 1.22, showing that multicollinearity was not a problem.

Multivariable analysis: independent predictors of camel mortality

The multivariable logistic regression model identified several independent predictors of camel mortality after adjusting for confounders (Table 3). In the unadjusted analysis, households in the Sool region had 6.73 times the probability of suffering camel mortality as those in Awdal ($p < 0.001$). After adjusting for potential confounders, the adjusted odds ratio increased to 7.74 ($p < 0.001$). Similar patterns have been noted in Nugaal (COR = 3.87; AOR = 4.12, $p < 0.001$) and Sanaag (COR = 3.90; AOR = 4.07, $p < 0.001$). In contrast, households in Gedo had decreased chances of mortality in the crude analysis (COR = 0.53, $p < 0.001$), and this protective association was retained after correction (AOR = 0.61, $p = 0.008$).

Livelihood was also a strong predictor. Unadjusted, nomadic families had over three times the odds of reporting camel

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TABLE 1 Socio-demographic characteristics of study participants.

Characteristic	Category	Frequency	Percentage (%)
Type of residence	Urban	939	15.85
	Rural	1,685	28.44
	Nomadic	3,301	55.71
Sex of household head	Male	3,950	66.67
	Female	1,975	33.33
Age of household head	<30	829	13.99
	30–40	1,928	32.54
	41–54	1,376	23.22
	>54	1,792	30.24
Household size	1–4 members	1,940	32.74
	5–8 members	3,106	52.42
	9+ members	879	14.84
Wealth index	Poor	4,790	80.84
	Middle	972	16.41
	Rich	163	2.75
Toilet facility	Improved sanitation	1,109	18.72
	Unimproved sanitation	4,816	81.28
Water source	Improved water source	2,567	43.32
	Unimproved water source	3,358	56.68
Asset ownership	Owns any asset	4,266	72.00
	Owns No asset	1,659	28.00

TABLE 2 Variance inflation factor.

Variables	VIF	1/VIF
Type of residence	1.624	0.616
Toilet facility	1.565	0.639
Wealth	1.393	0.718
Region	1.09	0.918
Household size	1.086	0.921
Asset ownership	1.072	0.933
Water source	1.072	0.933
Sex of household head	1.068	0.936
Age of household head	1.023	0.978
Mean VIF	1.221	

mortality compared to urban households (COR = 3.34, $p < 0.001$). This variable remained a robust predictor in the adjusted model (AOR = 2.87, $p < 0.001$). Furthermore, the likelihood of camel death increased with the age of the household head. This pattern was significant in both the unadjusted analysis (e.g., COR = 1.35 for the >54 age group) and continued after adjustment, with households led by individuals aged 41–54 (AOR = 1.52, $p < 0.001$) and >54 (AOR = 1.55, $p < 0.001$) having significantly higher odds of loss than the youngest group.

Several characteristics that were significant in the unadjusted study, such as wealth (COR = 0.45 for rich vs. poor), access to unimproved sanitation (COR = 2.11), and male-headed households (inverse COR = 0.83 for female), lost statistical significance in the adjusted model.

This shows that their initial association with camel mortality was likely confounded by stronger factors such as geographic location, nomadic livelihood, and household head age.

Discussion

This study presents a fresh, nationally representative examination of the causes of camel mortality in Somalia. By focusing exclusively on homes that have lost camels, the study delves deeper into the factors that contribute to drought being the leading cause of mortality. The findings show that drought is responsible for over half (45.91%) of all reported camel death, and that this attribution is systematically related to a household's geographic location, nomadic livelihood, and head age. These findings reframe our understanding of pastoral vulnerability, implying that risk is defined not only by the occurrence of a

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TABLE 3 Bivariate and multivariable logistic regression analysis of factors associated with camel mortality.

Characteristic	Category	Crude odds ratio (COR) [95% CI]	p-value	Adjusted odds ratio (AOR) [95% CI]	p-value
Region (Ref: Awdal)					
	Woqooyi Galbeed	1.93 [1.43–2.59]	**<0.001**	2.08 [1.53–2.83]	**<0.001**
	Togdheer	2.81 [2.14–3.69]	**<0.001**	3.16 [2.37–4.21]	**<0.001**
	Sool	6.73 [5.07–8.92]	**<0.001**	7.74 [5.76–10.41]	**<0.001**
	Sanaag	3.90 [2.93–5.18]	**<0.001**	4.07 [3.02–5.49]	**<0.001**
	Bari	1.56 [1.10–2.21]	**0.013**	1.40 [0.97–2.02]	0.071
	Nugaal	3.87 [2.81–5.35]	**<0.001**	4.12 [2.93–5.80]	**<0.001**
	Mudug	3.14 [2.29–4.31]	**<0.001**	3.90 [2.77–5.48]	**<0.001**
	Galgaduud	1.13 [0.83–1.54]	0.442	1.32 [0.95–1.83]	0.093
	Hiraan	0.74 [0.53–1.04]	0.082	0.76 [0.53–1.08]	0.126
	Middle Shabelle	0.08 [0.03–0.22]	**<0.001**	0.09 [0.03–0.24]	**<0.001**
	Banadir	0.68 [0.40–1.14]	0.141	1.38 [0.79–2.39]	0.259
	Bay	1.62 [0.90–2.91]	0.106	3.20 [1.72–5.94]	**<0.001**
	Bakool	2.39 [1.75–3.28]	**<0.001**	2.61 [1.88–3.64]	**<0.001**
	Gedo	0.53 [0.37–0.75]	**<0.001**	0.61 [0.42–0.88]	**0.008**
	Lower Juba	0.71 [0.38–1.32]	0.277	0.74 [0.39–1.40]	0.348
Residence (ref: Urban)					
	Rural	1.07 [0.90–1.27]	0.467	0.84 [0.68–1.04]	0.104
	Nomadic	3.34 [2.85–3.90]	**<0.001**	2.87 [2.29–3.60]	**<0.001**
Age of HH head (ref: <30)					
	30–40	1.09 [0.93–1.29]	0.282	1.18 [0.97–1.42]	0.094
	41–54	1.26 [1.06–1.50]	**0.008**	1.52 [1.24–1.86]	**<0.001**
	>54	1.35 [1.14–1.59]	**<0.001**	1.59 [1.31–1.92]	**<0.001**
Sex of HH head (ref: Male)					
	Female	0.83 [0.74–0.93]	**<0.001**	0.99 [0.87–1.12]	0.837
Wealth (ref: Poor)					
	Middle	0.55 [0.48–0.64]	**<0.001**	0.90 [0.75–1.09]	0.303
	Rich	0.45 [0.32–0.63]	**<0.001**	0.83 [0.56–1.23]	0.361

Ref., Reference Category (Odds Ratio = 1.0). AOR, Adjusted Odds Ratio; COR, Crude Odds Ratio; CI, Confidence Interval; HH, Household. Bold values indicate statistically significant results at $p < 0.05$.

shock, but also by the structural and socioeconomic constraints that limit a household's ability to mitigate it (Ahmed et al., 2025). This aligns with recent empirical evidence from Somaliland, which identifies geographic hotspots and environmental determinants as the primary drivers of camel loss, often independent of a household's individual socio-economic status (Hassan and Salih, 2026).

The most significant finding is that drought-related mortality varies geographically. In certain areas, the multivariable analysis showed significantly higher odds of attributing camel deaths to drought. Notably, compared to the reference location of Awdal, households in Sool had 7.74 times the odds of attributing mortality to drought (AOR = 7.74, $p < 0.001$). Nugaal (AOR = 4.12, $p < 0.001$) and Sanaag (AOR = 4.07, $p < 0.001$) showed similar, but less severe, patterns of increased risk. This is consistent with the distinct 2019–2020 climatic footprint observed in northern and central Somalia, where severe rainfall deficits decimated pastures. It also aligns with research that shows these areas are the centers of compounding crises where long-term resource-based conflict and environmental degradation converge with intensifying climate

shocks (Thalheimer, 2023). Conversely, the protective impact shown in Gedo implies that regional contexts involving better rainfall access, proximity to riverine ecosystems, stronger transboundary resource management and local adaptation may improve environmental sustainability and human wellbeing (Defere et al., 2024).

This study presents an intriguing paradox about nomadic ways of life. Although mobility is a crucial resilience trait, nomadic households were 2.87 times more likely than urban households to attribute their camel losses to drought (AOR = 2.87, $p < 0.001$). This finding is consistent with recent evidence from Somaliland, where nomadic status was a primary driver of increased camel mortality (Hassan and Salih, 2026). This finding aligns with evidence that pastoral mobility in the Horn of Africa is increasingly curtailed by biophysical challenges and shifting land-use patterns, transforming a traditional strength into a potential liability during extreme events (Treydte et al., 2026). When movement is restricted, the inability to "navigate" out of drought-stricken zones strains animal health and isolates households from adaptive services (Stacey et al., 2025).

The higher vulnerability of households led by elderly people (AOR = 1.59 for over-54 age group) is also substantial. This may represent a disjunction between traditional ecological knowledge and the exceptional severity of current climate extremes, as well as reduced physical capacity for the intensive labor required to sustain herds during a crisis (Vogt et al., 2024). Notably, wealth lost statistical power in the adjusted model, suggesting that individual household assets provide inadequate insulation against community-wide (covariate) shocks. This emphasizes that resilience is less a result of individual capital and more a consequence of the stability of broader socio-ecological and governance systems (Berhanu et al., 2024).

The study's conclusions have important implications for creating interventions. Conventional risk-sharing systems are inadequate for covariate risks like drought, making formal risk transfer methods essential (Vyas et al., 2021). Index-Based Livestock Insurance (IBLI) offers a potent model by utilizing satellite-derived data (NDVI) to automatically reimburse pastoralists when conditions deteriorate, overcoming the high transaction costs of traditional insurance (Linhoff et al., 2023). However, establishing such systems in Somalia requires careful, localized execution to ensure credibility and trust. To implement IBLI effectively on the ground, policies must anchor these products in *Takaful* (Islamic cooperative insurance) principles to align with regional religious and cultural values. Furthermore, implementation should heavily utilize Somalia's robust mobile money infrastructure (e.g., platforms like EVC Plus or Sahal), which allows for low-cost premium collection and automated payouts directly to remote nomadic herders. Finally, rather than relying solely on formal state institutions which may lack reach in remote regions, governments and NGOs must co-design and implement these systems alongside trusted local governance mechanisms, including customary clan-based *Xeer* systems and established local community-based organizations, to verify pastoralists' statuses and mitigate disputes.

Beyond formal insurance, innovative community-based methods are critical for post-shock recovery. The practice of camel leasing in Somali villages provides a culturally embedded avenue for resilience, enabling impoverished households to borrow nursing camels from wealthier relatives to rebuild herds and maintain nutrition (Decker et al., 2025; Farah et al., 2004). This mechanism combines social capital with economic opportunity, supplementing formal institutional safety nets.

Finally, the study underlines the value of proactive coping. Successful drought management requires the integration of humanitarian and development aid with improved early warning systems (Mohamed et al., 2025). Tailored climate forecasts can inform proactive interventions, such as early de-stocking and market support, which allow pastoralists to make educated decisions before crises worsen and prices collapse (Funk et al., 2023). Interventions must therefore concentrate on bolstering the overall market and information ecology rather than offering only reactive emergency assistance.

Limitations, and future research

This study's main strength is its use of the strong, nationally representative SDHS dataset, which allows for generalizable results. However, limits must be recognized. The study's design evaluates the conditional probability of drought as the cause of death, rather than the total risk of mortality. The data's cross-sectional and self-reported form further rules any causal inference. Furthermore, standard survey datasets like the SDHS lack granular variables critical to pastoralist livelihoods, such as individual household access to specific pastures, local conflict occurrences, and proximity to targeted emergency programs. These unobserved variables limit the ability to fully capture the localized socio-ecological drivers of mortality. Future study should attempt to integrate longitudinal data with high-resolution climate and conflict data in order to model these complicated connections more dynamically. Furthermore, specific studies are required to investigate the feasibility and cultural appropriateness of adopting IBLI and formalizing camel leasing programs in the Somali setting.

Conclusion

This study demonstrates that drought-related camel mortality is a widespread crisis in Somalia, affecting nearly 46% of camel-owning households. The findings reveal that this mortality is not uniform across the country but is heavily concentrated in specific geographic hotspots. Households in the Sool, Nugaal, and Sanaag regions face the highest risk, with Sool reporting a staggering mortality rate of nearly 73%. These results indicate that regional environmental conditions and local constraints create pockets of extreme vulnerability that traditional pastoral coping mechanisms are currently unable to overcome.

A significant finding of this research is the vulnerability of nomadic households, who are nearly three times more likely to report camel losses than those in urban settings. This suggests that the traditional nomadic advantage of mobility has become a liability during modern, prolonged droughts. Furthermore, the

study identifies the age of the household head as a critical factor, with households led by individuals over 54 years being significantly more susceptible to livestock loss. This highlights a growing gap between traditional management knowledge and the increasing severity of climate shocks, as well as the physical labor limitations faced by older pastoralists.

Crucially, the multivariable analysis shows that household wealth and the sex of the household head do not independently protect camels from drought-related death. When geographic and livelihood factors are accounted for, even "rich" households suffer significant losses. This reframes camel mortality as a systemic failure rather than an individual economic one. It proves that drought in Somalia is a community-wide shock that transcends individual household assets, underscoring the urgent need for structural interventions rather than relying on private household resources.

Recommendations

Policymakers should prioritize the regions identified as high-risk hotspots, particularly Sool, Nugaal, and Sanaag. There is an urgent need to establish spatially focused Index-Based Livestock Insurance (IBLI) programs in these areas. By using satellite data to trigger automatic payouts when grazing conditions deteriorate, these programs can provide pastoralists with the liquidity needed to keep animals alive before they reach the point of mortality. To ensure practical implementation, these insurance frameworks must be delivered via digital mobile money platforms and integrated within local Islamic financial (*Takaful*) and customary (*Xeer*) institutions to establish trust. These efforts must be supported by localized early warning systems that provide actionable information specifically for camel management.

Interventions must be specifically tailored to the nomadic and elderly-led households identified as the most vulnerable in this study. For nomadic groups, the government should focus on securing grazing routes and resolving resource-based conflicts that currently limit safe movement. For households led by older individuals, targeted assistance programs, such as labor support for herd management or direct feed subsidies should be implemented. Additionally, community-based recovery systems, like camel leasing, should be formalized to help these specific groups rebuild their herds after a drought.

To reduce the high mortality rate observed in this study, the focus must shift from reactive emergency aid to proactive market-based solutions. We recommend investing in market infrastructure that facilitates "early destocking." By creating an environment where pastoralists can sell a portion of their herd at fair prices at the onset of drought, households can preserve their economic value in cash rather than losing it to animal death. Strengthening the governance of water and grazing resources will ensure that the remaining "ship of the desert" assets can survive the increasingly volatile climate of the twenty-first century.

Data availability statement

This research did not involve the collection of primary data. The findings are based on secondary data from the 2020 Somali Demographic and Health Survey (SDHS), which is publicly accessible via the DHS website: https://microdata.nbs.gov.so.

Ethics statement

The studies involving human participants were reviewed and approved by the ICF Institutional Review Board (Rockville, MD, USA) and the Somali National Bureau of Statistics (Mogadishu, Somalia). Informed consent was obtained from all participants by the original survey implementers before data collection. This study is a secondary analysis of that anonymized, publicly available dataset. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Ethical approval was not required for the study involving animals in accordance with the local legislation and institutional requirements because this study is a secondary analysis of anonymized data from the 2020 Somalia Demographic and Health Survey (SDHS). The research did not involve any direct interaction with, or experiments on, live animals. All information regarding camel mortality was self-reported by human household representatives during interviews conducted by the Somali National Bureau of Statistics. Ethical approval for the original survey was obtained by the ICF Institutional Review Board and the Somali National Bureau of Statistics.

Author contributions

Conceptualization, MO; methodology, MH; formal analysis and interpretation of data, MO and AM; investigation, MO; data curation, MO; writing—original draft preparation, MO and MH; writing—review and editing, AM, MH, and MO; visualization, MO; supervision, AM. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

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