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Insights into pastoralist households' coping and adaptive strategies during northern Kenya's 2019–2022 drought

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This study is part of a long-term monitoring effort (34 years) of pastoralist households in northern Kenya affected by a series of droughts over the past four decades. The present paper investigates how these same households coped with and adapted to the prolonged drought from 2019 to 2022. The study posed three main questions: To what extent does environmental vulnerability influence species-specific coping and adaptive strategies? How did household labour arrangements and herd mobility decisions influence drought management? To what extent do land-use changes, fodder management practices, and livestock market price fluctuations influence herders' coping and adaptive strategies? Using mixed methods—household surveys involving 234 households, focus group discussions, and key informant interviews—the research findings highlight interlinked dimensions of drought coping and adaptation. The findings reveal stark species-specific vulnerabilities: cattle and sheep suffered extreme mortality, whereas goats and camels showed resilience due to their tolerance of water scarcity and diverse forage. Labour dynamics shifted as traditional family labour declined, replaced by monetized hired herders and cooperative arrangements, though high turnover and costs undermined effectiveness. Land-use changes, including semi-private range enclosures and crop cultivation, failed to mitigate the impacts, but women-led fodder-banking groups emerged as innovative resilience strategies. Market dynamics compounded stress, with distress livestock sales at declining prices deepening household indebtedness and eroding livelihood security. Community narratives highlighted ecological collapse marked by widespread pasture loss, water scarcity, and tree mortality, underscoring the need for transformative adaptation. Herd diversification, particularly the growing role of camels, and gendered initiatives such as fodder banking were central to resilience. Overall, the study demonstrates that pastoralists are not passive victims but active agents of adaptation, innovating through labor reorganization, collective action, and multi-species herd strategies to sustain livelihoods under intensifying drought conditions.

KEYWORDS

drought coping, drought coping strategies, fodder banking, herding labour, socio-economic and environmental vulnerability

Introduction

The subject of climate variability and climate change, and their linkages to drought, is inherently scalar, requiring readers to envision changes across time and space—local, regional, and global. While climate variability refers to short-term fluctuations in rainfall and temperature, long-term climate change, which persists over decades and centuries and spreads geographically, is the cause of droughts worldwide. For example, in Africa, meteorological droughts are lasting longer, reshaping vulnerability patterns across pastoral and agricultural systems (Lombe et al., 2024). These processes can compound the effects on pastoralism, with climate change increasing the likelihood of multi-year droughts that overlap with variability-driven shocks (Vázquez et al., 2017). In this study, our focus is on local and regional drought events that influenced coping and adaptive strategies among African pastoralist peoples (Ifejika Speranza, 2010; Opiyo et al., 2015; Bobadoye et al., 2016; Mwangi, 2016; Quandt, 2021; Mekuyie and Mulu, 2021; Pickering, 2021).

Droughts can range from mild to severe (Huho et al., 2010; Mortimore, 2010; Duba, 2024). A severe drought lasting three to 4 years can collapse the pastoral economy (Oba, 2024). It typically develops slowly, with irregular, isolated rainfall showers that attract mobile herders, leading to overuse of water sources and rapid overgrazing of emerging vegetation, followed by a dry spell that drives herders to desperate measures. Most critically, at extreme levels, drought gradually depletes surface water, dries out natural habitats—prompting herders to relocate to other areas (Ndlovu, 2019; Lutta et al., 2020; Duba, 2024). Thus, in drought-prone regions, erratic and unreliable rainfall increases pastoralists' vulnerability (Mauerman et al., 2023), prompting pastoralists to adopt strategies commensurate with their short-term coping and long-term adaptive capacities (Orindi et al., 2007; Korir, 2019), which vary across agro-ecological zones (Mwangi, 2016; 2019; Pickering, 2021; Mauerman et al., 2023; Busker et al., 2023; Oba, 2024). An important question remains: what happens when drought coping and adaptive strategies fail to meet the ecological and socio-economic challenges faced by individuals and communities? As drought severity intensifies over time, ecological deterioration and socio-economic pressures on pastoral households co-occur: with limited pasture, more livestock perish, and additional resources are spent on purchasing animal feed to supplement the nutritional needs of starving animals (Smucker and Wisner, 2008; Steinfeld, 2003). This situation worsens when the environmental and economic costs of drought increase disproportionately (Derbyshire et al., 2024), forcing families to dispose of their stock at unfavourable prices (Corbett, 1988).

Pastoralists are, however, not passive victims; rather, they respond to opportunities by adopting innovative coping and adaptive strategies that foster continuous learning, integral to their lived experience (Wang et al., 2025). For example, key indicators of drought management, including herding labour, herd mobility, and the distances livestock travel to access water and pasture (Bassett, 1994; Gikaba et al., 2014; Butt, 2016; Turner and Hiernaux, 2008; Turner and Schlecht, 2019), can be used to assess the performance of drought adaptations. Furthermore, families who previously had access to local pastures—now degraded by drought—respond promptly, either moving herds to other areas or intensifying local adaptive strategies (Homewood and

Rodgers, 1987; Mwangi and Ostrom, 2009; Reid et al., 2014; Amphlett, 2017). Additionally, pastoralists are taking advantage of land tenure and technological changes, such as range enclosures and fodder banking, to improve forage conservation (Wairore et al., 2015), or to purchase fodder from markets (Kimaru et al., 2021; Golman and Riosmena, 2013). At the household level, fodder management often involves intensive activities by family members to feed weakened animals (Hundera, 2010; Oba, 2024; Hezron, et al., 2024; 2025). Given the greater variability in drought adaptations, it is crucial to document the characteristic features of pastoralists' coping and adaptive strategies under extended drought conditions (Sintayehu et al., 2025). We emphasize how coping and adaptive strategies by individuals and the collective vary across space and time (see also Mohamed, 2026).

Contextually, this study contributes to regional historical scholarship on drought management in southern Ethiopia and northern Kenya (Oba, 2024). It is a part of a monitoring system set up three decades ago. For the purpose of the present article, our focus is on household and community-wide experiences of the 2019–2022 drought in the Obbu region of Northern Kenya. It investigates the vulnerabilities of pastoralism to prolonged droughts and the determinants of the success or failure of drought-coping and adaptive strategies at the individual and community levels (Ndiritu and Ruhinduka, 2019). We address the following three multivariate research questions. First, to what extent does socio-economic vulnerability and environmental variability influence species-specific coping and adaptive strategies? Second, how did household labour arrangements and herd mobility decisions influence drought management? Third, to what extent do land-use changes, fodder management practices, and livestock market price fluctuations influence both coping and adaptive strategies of herders?

The paper is organised as follows. We first present a brief overview of the conceptual framework. In the second section, we outline the methodology and provide brief descriptions of the study sites, followed by methods for addressing the three research questions on environmental vulnerability, labour dynamics and herd mobility decisions, and land use change and fodder management systems. In the third and subsequent sections, we present the findings and discuss the results thematically. The next subsection summarizes and concludes the study by highlighting key research findings.

Conceptual framing

This study is grounded in the pastoral resilience dimensions of drought adaptation (Birhanu et al., 2017), which integrate environmental vulnerability and variability with labour dynamics and socio-economic coping strategies in drought-prone pastoral systems. These dimensions are framed by livelihood diversification theory (Sen et al., 2026). Livelihood diversification theory explains how households—especially in rural and vulnerable settings—spread their income sources across multiple activities to reduce risk, enhance resilience, and improve food security. It emphasizes that diversification is not just an economic choice but is shaped by ecological stress, institutional environments, and social networks. This situates livestock loss, distress sales, debt accumulation, and

women-led fodder banking initiatives within broader survival strategies (Kassie et al., 2017). However, the political ecology of pastoralism offers a lens for examining land-use changes and fodder conservation as adaptations that restructure access to resources (Blaikie, 1995). The “political ecology of pastoralism” is best defined as an analytical framework that examines how pastoral livelihoods are shaped by the interplay of ecological conditions, political power, historical legacies, and social inequalities (Greenberg and Park, 1994; Robbins, 2019). It highlights that pastoral vulnerability and resilience are not purely environmental but deeply political and institutional. Pastoralists’ ability to use grazing lands, water points, and migration routes is mediated by state policies, customary institutions, and external interventions. Land tenure reforms, enclosures, and conservation projects often restrict mobility and reshape pastoral strategies Benjaminssen and Svanstad (2021). Resource scarcity and overlapping claims (e.g., grazing vs. farming, pastoralists vs. farmers) generate contestation, which is negotiated through customary institutions or leads to open conflicts between individuals. We clarify these further by defining the concepts: vulnerability, environmental variability, and coping and adaptive strategies.

Defining concepts

Vulnerability is the extent to which households, communities, or ecosystems are exposed to stresses (such as drought), sensitive to their impacts, and limited in their capacity to cope with or adapt to them (Adger and Brown, 2009). Its contextual dimensions include exposure, the frequency and intensity with which a system faces hazards (e.g., repeated drought cycles), and sensitivity, which reflects the strength of the system’s response (e.g., cattle mortality rates vs. camel resilience). To operationalize this, we will use measures such as livestock losses and reliance on distress sales as indicators of vulnerability (Herrero et al., 2016).

Environmental variability is defined as the degree of divergence in both physical feed availability and household strategies for securing feed (Nangole et al., 2013). It characterizes the processes that trigger environmental and socio-economic vulnerability. The former refers to fluctuations in ecological conditions—such as rainfall, pasture availability, and access to water—that shape resource distribution and household strategies over time and space. Dimensions of environmental variability include temporal variation, such as seasonal and interannual changes (e.g., wet vs. dry-season pasture), and spatial variability, which refers to differences across ecological zones (e.g., semi-arid vs. very arid agro-ecological zones). Spatial and temporal variability affect access to markets for feed and water (Turner and Schlecht, 2019). In operationalizing the concept of variability, we compared performance across livestock species (cattle vs. sheep vs. camel vs. goats), linked to ecological stressors, labour dynamics, and socio-economic outcomes (e.g., distress sales). The effects of environmental variability are reflected in distances to water points, household-level differences in access to feed, and grazing mobility. Other sources of variability in pastoral systems include: availability of grazing biomass; access to water; and the seasonal reliability of animal feed (Gilhaus and Hölzel, 2016; Valbuena et al., 2010).

Coping strategies are reactive measures adopted during prolonged drought (Ifejika Speranza, 2010). Examples include selling livestock at

low prices (distress sales) to buy food and trekking livestock longer distances to reach water and pasture. Other indicators of coping strategies include the distance to water, measured in kilometres walked, and the frequency of watering (Räsänen et al., 2018). Market dependence may also be included, measured by the proportion of households purchasing supplementary feed (hay).

Conversely, adaptive strategies are transformative actions taken by individuals and communities to reduce vulnerability to drought impacts (Mwakaalongo and Chingonikaga, 2023). These strategies focus on long-term goals and institutional transformations, such as women’s fodder banking. This approach captures not only ecological differences between agro-ecological zones but also socio-economic disparities in households’ coping capacity (Schmidt and Pearson, 2016). In this research, we also consider the labour process as an adaptation to environmental variability, informing the analysis of shifts in family labour, cooperative labour arrangements, and hired labour for herding (Naess, 2012). What, therefore, are the assumptions of the conceptual framing in the present research?

The conceptual framing makes five main assumptions about socio-economic vulnerability, environmental variability, and coping and adaptation strategies. The first is that climate variability and climate change are scalar processes. This implies that droughts must be understood across multiple scales (local, regional, global). Local drought events (such as 2019–2022) are nested within broader climate change trends that increase the likelihood of multi-year droughts. This frames pastoral vulnerability as both immediate (seasonal rainfall failure) and structural (long-term climate shifts). The second is that pastoral resilience is multidimensional. This assumes that resilience integrates environmental vulnerability, labour dynamics, and socio-economic coping strategies. Coping and adaptation are therefore not isolated but interlinked processes shaped by ecological stress, household labour availability, and market pressures. The third assumption concerns how political ecology shapes access to resources. This assumes that drought impacts cannot be separated from power relations, land tenure, and general resource access rights. The fourth assumption is that pastoralists are active agents, not merely passive victims. This assumes that households innovate continuously—through herd diversification, fodder banking, and collective action. The fifth assumption is that livelihood diversification is central to survival. This assumes that socio-economic strategies (livestock sales, debt, fodder purchases) are integral to coping. Gendered initiatives (women-led fodder banking), as framed in adaptive innovations, expand household survival options. As should be understood, many of the outcomes are interpreted from herder experiences, which limits direct measurement.

Methodology

Study area

The study was conducted in Sololo, Marsabit County, Northern Kenya. The Obbu Borana, the main residents, practised a mixed agro-pastoral economy, with residents settled across ten locations (Figure 1). Since 2010, a highway connecting the region to Marsabit and Moyale, as well as to the cross-border area with southern

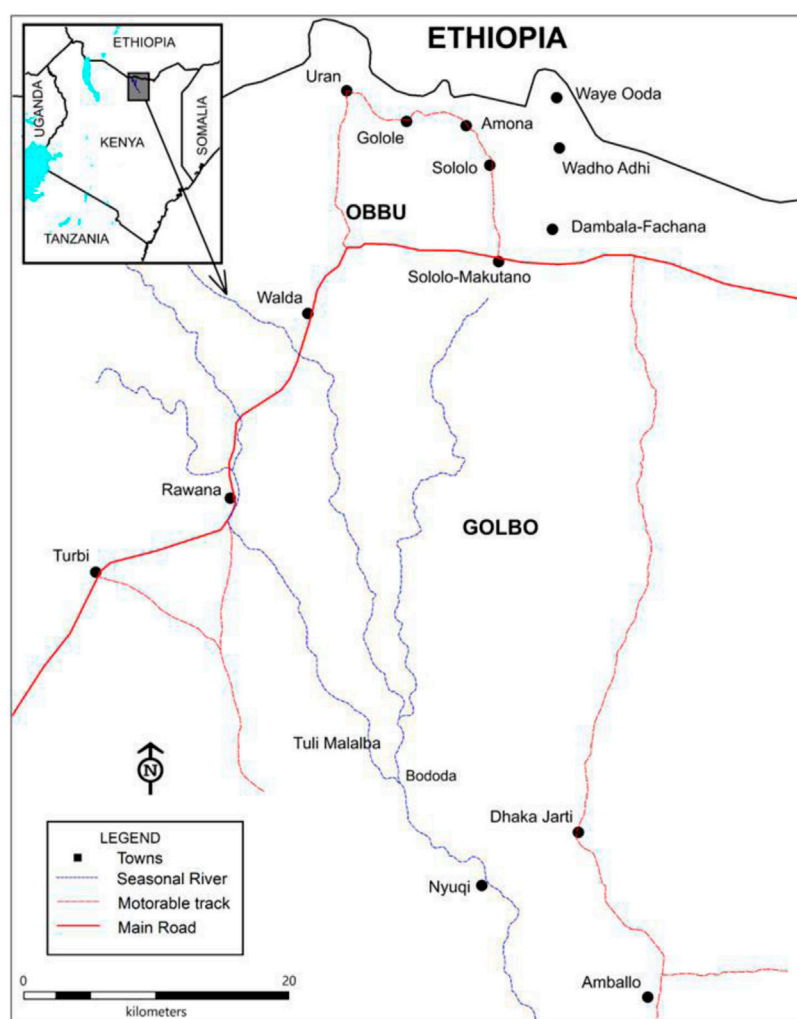


FIGURE 1
Map of the study area.

Ethiopia, has improved communication and trade. The region is agroecologically divided into semi-arid (Waye Godha, Anona, Sololo-Ramata, and Uran), arid (Mukutano, Dambala Fachana, Golole, and Mado Adhi), and very arid (Ambalo and Walda) areas. In semi-arid areas, land use is mainly crop cultivation and range enclosures, whereas the arid and very arid areas are mostly utilised for mobile livestock management.

According to 2019 census estimates, the population of Sololo sub-county, which is part of the Obbu region, was 44,822, with a population density of 7.5 per km². Livestock remains the primary source of income for the Obbu Borana, supporting households whose productivity depends heavily on variable rainfall. Crop farming is successful only once every 4 years (Oba, 2024). Over the past two decades, population growth and improved marketing opportunities have dramatically altered land-use patterns associated with farming and range enclosures (kaalo). The farms and private range enclosures now cover more than 600 km² of the Obbu region (Oba, 2024).

Rainfall in the region is erratic. In normal years, rainfall (250–400 mm) is bimodal—short rains, expected between

October and December, and long rains, expected between March and May—when pasture and water supplies from dams and seasonal rain pools are sufficient for the herds. In the region, drought manifests as follows. The short rains, as expected, may fail, leaving only isolated showers that disperse herders and increase environmental stress. The long rains may also fail. Consequently, surface water in the dams dries up, and the pasture from the previous year becomes exhausted. This results in a 1-year drought. Conditions worsened the following year, which was also dry, culminating in a severe drought during the third and fourth consecutive dry years. For water supplies during the dry and drought years, reliance is mainly on diesel-engine and solar-panel-operated boreholes. The condition of natural pastures and water availability influence livestock mobility and the distances walked, which in turn affect livestock body condition and survival. Economically, the Obbu Borana are closely linked to local and regional markets for selling their produce and purchasing other goods their families need. Closer economic and social ties with urban and peri-urban areas have helped households

TABLE 1 Research methods, objectives, and outcomes.

Methods	What was achieved
Semi-structured household questionnaire (238 households)	Captured individual household experiences of drought, including livestock management, coping strategies, economic impacts, and decision-making during 2019–2022
	Ecological vulnerability assessment (species-specific analysis). Measured livestock mortality, distances to water, fodder availability, and species tolerance to drought stress (e.g., cattle vs. camels vs. goats). Measured livestock mortality, water access distances, fodder availability, and species tolerance (cattle vs. camels vs. goats). Produced comparative vulnerability profiles across agro-ecological zones
Focus group discussions (FGDs) (3 group gatherings)	Gathered collective community perspectives, narratives, and shared coping strategies; highlighted gendered roles (e.g., women gathering hay, men lopping foliage) and community-level innovations like fodder banking
Key informant interviews (KIIs) – 20 individuals	Provided expert and local leader insights into drought impacts, herd mobility, labour dynamics, and socio-economic transformations; contextualized household-level data with broader community knowledge
Mixed-data analysis methods	Integrated quantitative (mortality rates, distances to water, market prices) and qualitative (narratives, perceptions) data for a holistic understanding of ecological vulnerability and socio-economic coping

Source: Current survey.

diversify their livelihoods. In addressing the three multivariate research questions, we adopted the following sampling protocol.

Sampling protocol

For readers' background, the present study forms part of the long-term monitoring of 164 households across eight locations in the Obbu region, randomly selected during the initial sampling in 1983 and repeatedly visited and interviewed about their experiences, coping strategies, and adaptations to drought events over three decades (1983–2012). By following the economic successes and failures of individual households over this period, the aim was to determine how past experiences influenced household decisions, aspirations, and innovations during subsequent droughts (Oba, 2024). For the present purpose, building on this database, we used recall household data for the drought period of 2019–2022 and the post-drought period of 2023–2025, during which all historical households (from across eight locations) and an additional 74 new households, randomly selected from the settlements of Ambalo (64 households) and Walda (10 households), were included in the sampling protocol. For historical households in the monitoring protocol (excluding those that migrated) whose heads had passed away, we interviewed their children or surviving spouses. During data collection, we engaged local primary school teachers working within the study communities. Interviews were conducted in the Oromo dialect. Our assessments were guided by four sampling platforms (Table 1).

In the study design, each household in the sample was treated as an independent unit. The respondents were both men and women. In data collection, we used a semi-structured household questionnaire (234 households), Focus Group Discussions (3 groups, each comprising 12–20 individuals), Key Informant Interviews involving 20 individuals (both men and women), and analysis conducted using qualitative and quantitative methods

(Table 1). We analysed herders' experiences of how environmental vulnerability determines the sensitivities of different livestock species across agro-ecological zones by generating comparative profiles that reveal how environmental variability shapes household coping strategies. We investigated the effects of drought on the environment—namely, perceived indicators of degradation associated with drought, including pasture scarcity due to loss of grass cover (overgrazing) and tree mortality—and how these impacts influence herders' coping mechanisms—namely, the observed effects, the challenges encountered, and the solutions developed.

At the community level, we used focus group discussions (FGDs) and key informant interviews (KIIs) to respond to questions posed to individual households. While FGDs gave the community a voice, KIIs added structured expertise on community perspectives. We used this approach to gather stories about how the drought altered grazing lands, water access, and herd survival. We also investigated gendered roles, including how women and men contributed differently to managing drought-weakened livestock. We considered the strategies communities used to innovate drought management.

We investigated how managing livestock during droughts demands considerable labour, which most families lack; hence, the use of salaried herders. Readers are reminded that, in the traditional system, where the Borana used hired herders, remuneration for services rendered was in the form of heifers annually (Dahl, 1979). Presently, however, herding labour has been highly monetarised. Our goal was to understand the difficulties in recruiting herding labour—covering differences among hired, family, and cooperative labour—and to examine their experiences sourcing labour, including the limitations of these methods. Informants were asked to briefly describe how they managed their stock during droughts, the difficulties they encountered, the strategies employed (e.g., regional or local herd

TABLE 2 Ecological vulnerability matrix: livestock and agro-ecological zones.

Factors	Cattle	Goats	Camels	Sheep
Drought sensitivity	Very high – prone to starvation and water stress	Moderate – resilient, low feed needs	Low – drought-adapted, browse feeders	Highly sensitive to feed and water scarcity
Feed requirements	High – dependent on grass and water	Low – can survive on shrubs and minimal water	Moderate – browse and water-efficient	Moderate – needs grass and water
Mobility needs	High – requires long-distance movement	Moderate – adaptable to local mobility	Moderate – can travel far, but slower	High – often moved with cattle
Mortality during drought	Severe – high death rates in prolonged droughts	Low – often survive without supplementary feed	Low – high survival rates	Severe – similar to cattle
Economic loss	Very high–significant financial capital loss	Moderate – lower unit value but essential	Highly valuable but fewer owned	Moderate – culturally and economically important
Zone vulnerability	Semi-arid: high mortality Arid: Extreme stress	Semi-arid: resilient Arid: Adaptable	Arid: Best suited Semi-arid: viable	Semi-arid: vulnerable Arid: High risk

Sources: Current study.

movements), and the motivations for their management choices. We were especially interested in livestock watering schedules and the distances family herds travel to access water, as these distances influence adaptive strategies related to livestock's thirst tolerance and capacity to endure periods without water. These factors have important implications for energy requirements and the mortality rates of livestock weakened by drought-induced starvation (Western and Finch, 1986).

Additionally, we examined land-use changes related to farming and range enclosures and their effects on drought management. Specifically, we aimed to understand how crop cultivation and semi-private range enclosures contribute to land fragmentation, influence drought management strategies, and relate to long-term livestock feed management. We investigated how they supported fodder production and the challenges they faced across locations. We considered households' participation in fodder conservation groups involving both men and women. Further, we investigated the use of commercially supplied fodder and its economic impacts on household livelihoods. We also explored how droughts affected household income and the sources of income families relied on. In terms of socio-economic impacts, we asked families to recall their participation in purchasing commercial fodder for drought-weakened livestock, and the desperate measures individuals took to feed their stock. We addressed how drought affected household income and expenses, as well as impacts on livestock marketing before, during, and after the drought.

Our household data formed a socio-ecological series that was unsuitable for inferential statistics. We therefore used a non-parametric analysis because the data varied widely across households and locations and often contained gaps. By avoiding rigid statistical assumptions, we integrated both quantitative indicators (e.g., livestock mortality rates, distances to water, market prices) and qualitative narratives (e.g., community perceptions, coping stories, gendered roles) in our analysis, using frequency data. When analyzing FGDs and KIIs, we synthesized the general ideas presented across the region. Personal narratives were used to strengthen the arguments on coping and adaptive strategies.

TABLE 3 Perceived impacts of drought on the grazing lands.

Response factor	Frequency
Complete loss of vegetation cover/increased bare ground	66%
Rumprant overgrazing	27%
Loss of grass cover/pasture	18%
Trees die-back	7%
Water scarcity/pans dried up	6%
Bare soil	4%
Influx of livestock from elsewhere	3%
Others	2%

Source: Survey data.

Results and discussion

Vulnerability of livestock species to drought

Table 2 highlights species-specific drought vulnerability across agro-ecological zones. Indicators of ecological vulnerability were drought sensitivity, feed requirements, mobility needs, mortality during droughts, and economic losses across agro-ecological zones. Cattle suffered extreme mortality (80%–90%) and showed very slow recovery ($\approx 2.3\%$ annually), making them unreliable for short-term household recovery. Small stock (sheep and goats) experienced high losses (73.6%) but rebounded faster ($\approx 13.7\%$ annually), becoming vital for food security and liquidity. Camels remained the most resilient, with minimal mortality (45%). Cattle, with their slower regeneration rates, remain highly vulnerable to prolonged drought cycles, requiring sustained investment in fodder systems, veterinary support, and water infrastructure to stabilize populations. By contrast, small stocks demonstrate a comparatively rapid rebound, positioning them as critical assets in household coping and recovery portfolios. These species-specific dynamics suggest that pastoral households are increasingly compelled to diversify herd

composition, balancing the cultural and economic significance of cattle with the recovery potential of small stock.

Table 3's environmental indicators highlight severe environmental degradation during the 2019–2022 drought. Households reported widespread vegetation loss, with pastures drying up and failing to sustain herds. Water scarcity intensified as surface pools and dams dried up, forcing livestock to trek long distances to boreholes. These stressors drove extreme livestock mortality, especially among cattle and sheep (Wong et al., 2021). Overall, the indicators reveal high ecological stress, which, in the context of the present study, refers to the breakdown of rangeland ecosystems under prolonged drought stress. It is marked by the drying of surface water, widespread pasture loss, tree mortality, and soil degradation, leaving herders with few viable grazing options. In essence, ecological collapse signals that the environment temporarily lost the capacity to sustain pastoral livelihoods. The severity of the drought posed challenges for livestock management, given the interlinked effects of water shortages and pasture scarcity (Homewood and Lewis, 1987).

KIIs indicate that the loss of vegetation cover and the increase in bare soil are clearly linked, with one informant noting that “even grass litter could not be seen,” indicating that overgrazing during the drought was overwhelming. Poor rainfall in the years preceding the drought created preconditions for adverse environmental changes. The impacts included livestock starvation due to the stress of walking and expending energy without sufficient grazing to replenish them, and diseases that exacerbated livestock mortalities (Sintayehu et al., 2025). The long-term solution to drought vulnerability is to manage multiple livestock species, each of which responds differently to environmental stressors (Orindi et al., 2007). Camels demonstrate resilience due to their adaptation to their tolerance of thirst (George, 2024). Accordingly, as a long-term strategy, pastoralists combined grazers and browsers in their herd selections to optimise survival (Huho et al., 2023). This evidence is supported by the fact that in the Obbu region, the number of households owning camels has increased by 40% over the last decade (This study). A study from Uganda showed that a significant increase in camel holdings increased pastoralist resilience (Asiimwe et al., 2020). Volpato and King (2019) evaluated the 30-year process of adopting camel husbandry by a group of Kenyan pastoralists and demonstrated their multifaceted adaptations to climate variability. Thus, the rationale for diversifying herds is rooted in their different adaptive capacities—with some species, such as camels, being more resistant to drought stress than cattle and sheep (Sintayehu et al., 2025). Other forms of adaptation related to herd diversification were herd mobility.

Herd mobility

Traditionally, pastoralists have relied primarily on mobility to adapt to the spatial and temporal distribution of pasture and water. Common mobility strategies include seasonal migration between dry- and wet-season grazing zones and cross-border movements into Ethiopia. The choice of strategy is influenced by rainfall patterns, resource distribution, and security issues (Wario et al., 2016). Recently, the adoption of modern technologies, including trucks, motorbikes, and mobile phones, has improved communication about the distribution of grazing resources,

facilitating herd movement (Alemayehu et al., 2023). The extent of herd movement varies with drought severity (Golman and Riosmena, 2013). Timing is vital for livestock movement—different outcomes are expected during the early drought phase, when animals are in good to fair condition, versus the late drought phase, when their body condition deteriorates (Toulmin, 1995). Herders decide whether long-distance migration is appropriate, considering all relevant factors; hence, mobility strategies differ between families and between owners of large and small herds, with the latter favouring local management approaches (Oba, 2024). Therefore, local versus long-distance movement entails distinct risks, costs, and outcomes, necessitating decisions tailored to specific livestock species. Others risk long-distance migration by crossing international borders into regions where conditions are reported to be significantly better (Golman and Riosmena, 2013). According to FGDs, the challenges of long-distance herd movements include uncertainty over access to suitable pasture and water. These movements often require multiple relocations, each increasing pressure on the herds, as herders spend considerable time scouting for water and pasture, negotiating access, and investing resources in these efforts. At the same time, they must care for animals weakened by drought. Ultimately, these coping strategies often fail to preserve the stock, given the widespread environmental crisis (Oba, 2024). This was demonstrated during the study period, which revealed the limitations of traditional mobility under regional drought (Alemayehu et al., 2023). Herd mobility was closely tied to the availability of herding labour.

Herding labour

Pastoralism, by its nature, is labour-intensive (Sieff, 1999). Providing labour involves a range of efforts – from range scouting, herding and decision-making to ensuring the wellbeing of individual animals. In a diversified pastoral system where a herder manages sheep, goats (small stock), cattle, and camels, each species requires specialised labour. The herd owner, by balancing labour needs across different livestock species, aims to align labour requirements with environmental conditions that influence pasture and water availability across the grazing landscape, thereby relocating herds to suitable areas where they can maximise survival. However, this balance cannot always be maintained, given the variability of rainfall and the shifting demands of individual herds – especially when considering the suitability of different livestock species under changing environmental conditions (Sikana and Kerven, 1991).

In the Borana context, labour allocation within households is highly gendered and age-specific, with clear roles for men, women, youth, and elders. Men and older boys mainly handle long-distance herding and mobility decisions, while women and girls manage feeding calves and drought-weakened animals, collecting hay, and fetching water (Ndiritu et al., 2025). Under current conditions, three types of labour exist: family labour, cooperative labour, and hired labour. Family labour—the traditional backbone—is now in decline (58%). About 42% of households used hired labour. As younger generations pursue education or alternative employment, families are unable to recruit labour; instead, they rely on cooperative and hired labour. Both types of labour differ from the labour sharing

TABLE 4 Experiences and impacts of the 2019–2022 drought on the pastoral economy.

Factors	Response
Experiences reported	
Mass livestock deaths	88%
Starvation of herds and human hunger are prevalent	72%
Water scarcity	65%
Economic collapse/loss of income	60%
Crop failure	28%
How livestock was managed during drought	
Buying animal feed	91%
Cutting/lopping tree branches	78%
Collecting dry leaves/tree litter	36%
Sharing human food with livestock	42%
Water trucking	34%
Migrating to find a new pasture	30%
Management strategies used	
Mobility (searching pasture and migration)	66%
Local management (e.g., fencing kalo, feeding at home)	34%
To reduce walking energy for weak livestock	48%
To avoid long walks and save labour	42%
Local management is easier because there are fewer animals	28%
Mobility allowed access to pasture and water	66%
Type of labor	
Family labor	82%
Hired labor	18%
Average salaries (for hired labour)	
Most common range	KES 4000–5,000
Highest reported	KES 8000, ~3%
Rations provided	
Yes	72%
No	28%

Source: Survey data.

traditionally practised (Dahl, 1979). Currently, remuneration has shifted to cash wages, reflecting the monetisation of herding labour. While cash wages offer flexibility, they also impose financial strain on households (Sieff, 1999).

Table 4 shows how drought intensified environmental stress and labour challenges. Pasture scarcity and long distances to water increased herd vulnerability, while reliance on monetised hired labour proved costly and unstable. Cooperative herding offered partial relief (Malhotra et al., 2022). Beyond labour and cost sharing, cooperative herding has disadvantages for individual animal care, particularly when limited commitment reduces its

effectiveness relative to family labour (Naess, 2012). Since the labour recruitment method is relatively new, wages tend to be low (on average, less than 40 USD per person per month; see Table 4), and rations may be insufficient, especially during droughts when herd milk production declines. Consequently, these workers endure harsh living conditions away from home, with inadequate pay and limited rations, which can diminish their morale during droughts (Bassett, 1994). An additional challenge is sourcing hired labour, especially in the Obbu region, where it must be obtained across the Ethiopian border due to local shortages. Inexperience in managing hired labour and poor working conditions have led to high employee turnover. For herd owners, seeking replacements often yields unsatisfactory results. This is a common crisis, particularly during drought years, when hired labour decides to quit midway. The disadvantages notwithstanding, waged labour presents opportunities, potentially making pastoralism a new form of employment if competitive wages and improved working conditions are provided. In practice, this experience is widespread among other pastoralist communities (Butt, 2016), especially among wealthy stock-owning families (Brockington, 2006; Little, 1985), who are compelled to pay better wages. We next discuss how labour availability is crucial for livestock watering management.

Distances walked to water and watering intervals

Figure 2 illustrates how drought drastically altered herds' watering schedules. As surface pools and dams dried up, livestock were forced to trek longer distances to boreholes, increasing energy expenditure and further weakening already-stressed animals (Moke et al., 2016). We break down watering schedules by livestock species, reflecting differences in ecological tolerance and drought stress (Table 5). Distances and watering frequency are critical factors influencing herd survival (Ndathi et al., 2011). Cattle required frequent watering, often every 1–2 days, because of their low tolerance for thirst and dependence on nearby pastures. This left them highly vulnerable when water sources dried up and distances increased. Sheep and goats were watered at longer intervals, typically 3–4 days, and could tolerate moderate water scarcity. Camels showed the greatest resilience, enduring 7–10 days without water. The total distance walked reflects both household burden and livestock stress. Households often walk 10–20 km daily to access water, reducing time available for other livelihood activities, especially for women, who bear much of the burden of water fetching (Bedelian et al., 2024). Long treks to water sources lead to weight loss and increased susceptibility to disease (Western and Finch, 1986). Some households reported walking up to 60 km. In this context, the Borana practice a specialised system of watering schemes. They follow a 2-day walk to water with temporary camping, called *buulto*. The next day, they walk to the water and return to the temporary camp. The next day, they proceed to the grazing camp, and the process is repeated (Oba and Lusigi, 1987). These factors were aggravated by environmental deterioration during drought, described earlier, and changes in land use associated with the introduction of farming and range enclosures.

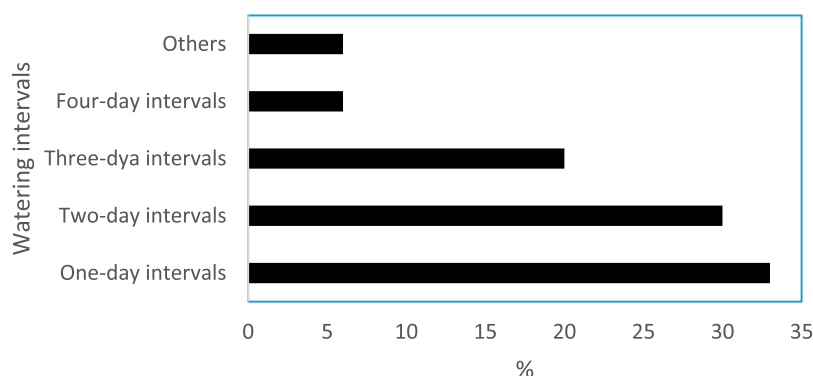


FIGURE 2
Livestock watering intervals.

TABLE 5 Percentage expenditures of households on drought mitigation.

Factors	Responses
Sources of family expenses	
Animal feed	94%
Veterinary drugs/treatment	58%
Water trucking	36%
Movement of livestock across county borders	22%
Reasons for increased expenses	
Buying feed and water	88%
Transport and labour costs	30%
Loss of income-generating activities	24%

Source: Survey data.

Landscape fragmentation and forage conservation

In the Obbu region, particularly in the semi-arid and arid zones, the expansion of farming and range enclosures (kaalo) has led to land use fragmentation. We examined why range enclosures failed to produce surplus forage for stock management. Based on individual household interviews, the greatest threats to forage production within enclosures are bush encroachment, poor maintenance practices, exclusionary land tenure, and high input costs (Figure 3). Among other factors, rainfall variability, pest damage, and bush encroachment remained the main constraints, reflecting ecological and management challenges. Together, these factors undermined the potential of enclosures to buffer households against drought. Furthermore, sustainable fodder management was constrained by labour shortages and limited finances, as preserving fodder requires substantial investment in fence construction and maintenance.

In normal years, a substantial majority (83.3%) of households retain fodder for their own use or explicitly state that it is not for sale, indicating subsistence-oriented management. Only 10% of households are involved in fodder sales. These households are

mostly those that lacked sufficient livestock to feed. Nevertheless, 18% of households practiced a mixture of preservation and selective grazing. The standard price was measured in units of 'backload' (*duuda*), carried by women, which is roughly equivalent to 20 kg of dry grass. The lowest reported price in the local market was KES 400, and the highest was KES 1500. According to the discussions (FGDs and KIIs), the main challenge was a lack of field-level fodder management, including knowledge of proper harvesting and baling methods. It is noted that the lack of storage infrastructure was the primary constraint on storing harvested grass in non-drought years, thereby limiting the ability to feed livestock during drought years. This was the view of one KII from Mukutano:

I lack a shed to store hay, so rain spoils the grass. The inability to build stores primarily stems from a failure to plan for the long term. We have not received sufficient training in constructing storage facilities. One option is for communities to collaborate on building shared stores where individuals can store their share of the hay, helping them preserve their livestock during future droughts.

Also, after losing the majority of their livestock, there was disinvestment and discouragement about maintaining range enclosures to sustain forage production. Other constraints on the range enclosures' failure to produce surplus forage include a lack of financial resources that prevents individuals from investing in fencing. This is how another KII responded to the question posed to him:

The leading causes of livestock deaths were water and pasture shortages. [Question] Could actions taken by communities during wet years help protect livestock during future droughts? [Response] Everyone, including pastoralists and the government, acknowledges that droughts are inevitable; however, proper preparation by both parties to prevent a drought-related disaster that could destroy livestock has not been implemented. One potential solution is for society to participate in fodder banking, with the government's role being to educate and train communities.

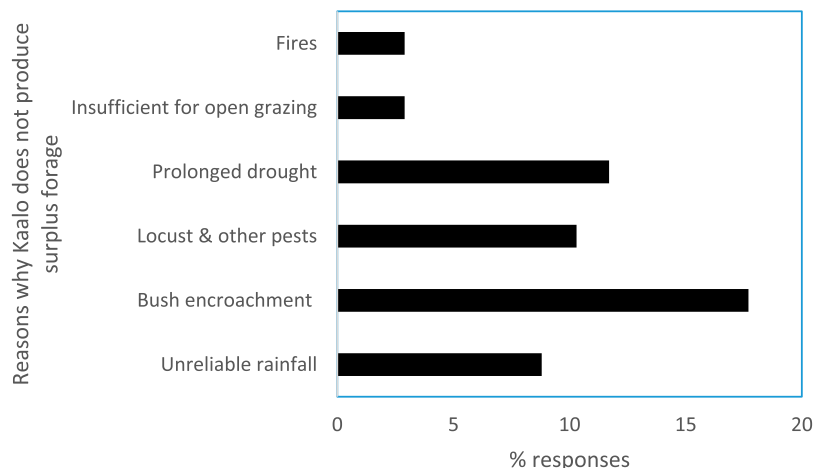


FIGURE 3
Reasons why kaalo failed to produce surplus forage.

Other challenges include frequent trespass by neighbours, which undermines the integrity of the enclosures. This, in turn, undermines effective management, as households are discouraged from investing in long-term fodder conservation due to the risk of loss. This deficit is, however, bridged by women's groups' innovation in fodder banking.

Fodder bank organizations

Women accounted for 96.67% of participants in fodder banking, and men for 3.33%. Traditionally, among the Borana, women are responsible for collecting hay for livestock, and, presumably, this principle of localising responsibility to women has extended to fodder conservation, particularly through women's groups. We interviewed the chairlady of the fodder banking group in Mado Adhi.

I called the women and shared this idea with them. After our discussion, they agreed to form a women's group to harvest grass. We then asked the chief and the community to allocate land for the project. The community agreed, and we were given land some distance from the settlement. We cleared a portion of that land, and during the next rainy season, grass grew and was harvested. The land was registered in the name of the Maliti Women's Group, which has 60 members. Over two seasons, we harvested more than 60 backloads of grass and sold it for 60,000 kesh. Since then, we have received training in baling hay and currently have 2,000 bales in storage, each priced at 400 kesh, for a total of 800,000 kesh.

For the herders of the Obbu region, adopting fodder production is a new system of resource use, partly because it incorporates conservation elements largely absent from the traditional system, at least on a large scale. This represents a new pathway to asset creation (Sala et al., 2020; Wasonga et al., 2016). Farmers and herders also agree that the most practical approach is to establish locally managed fodder banks, which would require planting fodder grass when conditions are favourable (Ndlovu, 2019; Kimaru et al., 2021). The

formation of fodder groups registered with the Department of Social Services would enable women to access external support for growing high-quality hay to fill gaps in local fodder markets (Sala et al., 2020; Ondiek et al., 2025). Therefore, understanding herders' perspectives and their willingness to address the challenges posed by fodder markets can help inform community-wide decision-making interventions (Sala et al., 2020).

Purchasing supplementary feeds

The main obstacles to households purchasing fodder include: the high cost of commercially supplied fodder (18.2%), seasonal feed shortages (18.2%), severe droughts (6.6%), and limited access to markets (12.2%). Households spent significant sums (e.g., KES 200,000 per lorry load of grass bales) to buy hay from distant regions such as Meru County in Kenya or from across Ethiopia. Let us use a narrative from one of the KIIs, interviewed in Mukutano:

Despite practicing long-distance migration, the stock continued to die. I eventually brought the remaining animals into my compound at Mukutano, where they continued to die in groups of five or eight a day. I bought hay delivered by lorries from other parts of Kenya, but this did not save them. My family then decided to feed the surviving animals boiled maize and beans. . . This effort helped save some of the cows.

Households increasingly relied on commercial fodder (hay and feed pellets) to sustain weakened animals. Purchasing supplementary feed was a reactive coping measure that helped households survive but also exposed them to economic stress. Purchasing animal feed was among the factors that triggered forced sales of drought-weakened stock.

Livestock sales

In almost all locations (e.g., Anona, Golole, Ramata, Waye, Uran, Walda, Mukutano, Dambala Fachana, and Ambalo),

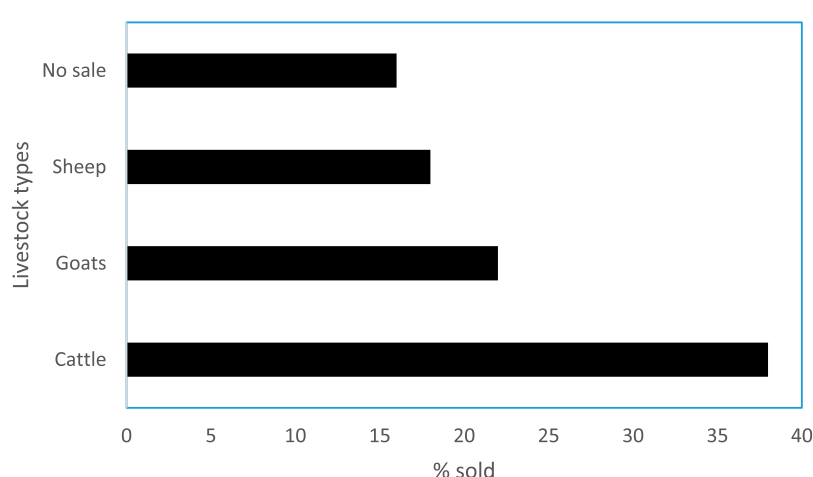


FIGURE 4
Livestock species commonly marketed by families during and after droughts.

respondents consistently reported selling drought-weakened livestock during and after the drought to purchase animal feed (Figure 4). The main challenge was reduced purchasing power among families due to low livestock prices (92%).

During the drought, cattle and sheep were sold most frequently, often at distress prices because of weakened body condition and oversupply in local markets. Individual households held the view that forced livestock sales during drought at “throwaway prices” created widespread destitution—affecting more than 80% of households in some locations (Table 5). The drought exhausted financial savings and forced many households to seek alternative informal livelihoods outside pastoralism (Homewood, 2018). For future drought management in Obbu, reducing reliance on costly short-term measures and investing in community fodder systems, water infrastructure, and herd diversification will be essential to lower household costs and strengthen resilience. Overall, the results show that drought mitigation expenditures were not only high but also unevenly distributed, with wealthier households better able to absorb costs, while poorer families faced debt and destitution.

Summary and conclusion

This study makes an important contribution to the field of drought coping and adaptation by individual pastoralists, demonstrating that their drought coping is not simply reactive but is actively shaped through innovation of adaptive strategies. Historical exposure to repeated drought cycles taught families which strategies were viable and which often failed. For example, earlier droughts had already revealed the vulnerability of cattle and sheep compared with the resilience of camels and goats, so many households entered the recent drought with a stronger emphasis on diversifying their herds. Similarly, long-term lessons about labour shortages and the decline of traditional family herding arrangements influenced the shift towards monetized hired labour and cooperative herding groups. Families remembered the difficulties of retaining herders in past droughts and thus weighed

the risks of high turnover and costs when deciding whether to rely on salaried herders.

Land-use changes also reflected accumulated experience. Earlier attempts at crop cultivation and semi-private enclosures had shown limited success in storing fodder reserves during the drought years. The shift from communal to semi-private grazing has increasingly fenced off land for exclusive use, fragmenting traditional open rangelands. With the expansion of range enclosures, herd mobility will be constrained, as enclosures limit movement across landscapes, reducing flexibility during future droughts. Thus, we see mixed outcomes. While enclosures allowed some fodder conservation during normal years, they often failed to mitigate drought impacts due to poor management and financial barriers. They also intensified competition and exclusion, reshaping social relations around land access. Instead, households leaned more heavily on innovations such as women-led fodder banking groups, which emerged as adaptive strategies informed by the failures of past coping mechanisms and have since become part of future drought management. By anchoring households to localized fodder sources, fodder banking will reduce the need for long-distance trekking, offering a more sedentary coping strategy. The challenge is balancing these emerging practices with the ecological necessity of mobility to avoid undermining long-term resilience. Together, they mark a transition from reactive coping (trekking, distress sales) to adaptive strategies (fodder reserves, diversification, collective innovation). Overall, the findings demonstrate that pastoralists are not passive victims of climate stress. Instead, they actively reorganize labour, diversify herds, and innovate through collective action to sustain livelihoods. The study concludes that resilience in drought-prone pastoral systems depends on integrating ecological knowledge, gendered initiatives, and adaptive diversification strategies to confront intensifying climate variability. It can also be inferred that households’ decisions during the 2019–2022 drought were not made in isolation—they were informed by cumulative lessons from past droughts, blending reactive coping with adaptive innovations.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The study was approved by the Jomo Kenyatta University National Research Ethics Committee and conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments, or comparable ethical standards.

Author contributions

GO, HW, and HR developed and discussed the study design. GO conducted the fieldwork and analysis, and HW and HR were involved in the writing process. 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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