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Temporal Drought Management for Sustainable Livestock Upkeep in Semi-Arid Areas of Kenya

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A B S T R A C T

The livestock sector in the semi-arid areas of Kenya is under increasing pressure due to climate change that often manifests in frequent and severe droughts. Human population upwards shifts and land tenure and use changes aggravate the problem, with the resultant heightened vulnerability denying the livestock segment its rightful place in the social and economic system in the region. This paper shares experiences based on a study directed at exploring drought related livestock management practices in the semi-arid areas with a focus on prevailing resilience, mitigation and recovery. The study took the case study of the Ikanga-Kyatune Ward in Kitui South of Kenya and administered structured questionnaires to households and key informants. The accrued data was analyzed through use of descriptive statistics. The findings show that the increasing drought episodes lead to a shortage of feed and water, which result in starvation and death of livestock, jeopardizing the living ways of people. Absence of comprehensive planning for drought is identified by 75% of the study participants to offer the highest limitation to sustainable livestock sector sustenance. The overall recommendation is on laying focus on proactive measures characterized by apposite planning to reduce the impacts of weather change on livestock. To enhance resilience, the study vouches for integrating livestock livelihood adaptation strategies into localized development plans and embracement of timely and well-informed decision-making, and region-specific interventions while carefully considering the trade-offs associated with the strategies.

Keywords: Climate variability; Livelihood; Resilience; Vulnerability; Adaptation.

1.0 Introduction

The livestock rearing sector in the semi-arid areas of Kenya serves as the most befitting practice in the ecological setting where it provides an appropriate primary mechanism of utilizing the grasslands, forage and salt licks. The tending is fundamental to the country's rising demand for meat and dairy products due to population and economic growth. However, the livestock livelihood sector in the milieu faces several changes, among them being the phenomenon of drought which has the most profound implications for sustainable livestock development and management. Drought occurrences do not have a clear onset and end, which makes it particularly testing to mitigate and manage (Ayugi *et al.,* 2022; Bandyopadhyay *et al.,* 2020). The complexity is compounded by the varying impacts, with its increasing frequency and intensity being exacerbated

by climate change. The results pose significant threats to the security of the social and economic roles of livestock, necessitating establishment and actualizing of effective management strategies tailored to the specific conditions of a region. Cognizance is sufficient quantity and quality of feed and water resources underpin livestock survival and productivity. Even when the volume of feed intake is high, low nutritional quality can constrain yields as livestock divert resources for lactation, weight gain, or reproduction to maintain normal body function. Poor nutrition jeopardizes animal health and can eventually result in morbidity and mortality, representing further productivity losses.

Droughts in the semi-arid areas lead to chronic pasture, forage and water scarcities. The high temperatures increase the rate of evaporation and alter precipitation patterns, intensifying the severity and frequency of droughts (Allen *et al.,* 2010; Hermans & McLeman, 2021). The subsequent effects have substantial implications for water supplies reliability with resultant negative impact on livestock, making communities end in food insecurity, increased poverty and displacement (Yaddanapudi & Mishra, 2022), revealing climate change as one of the major problems in the semi-arid ecosystem. Evidence indicates that climate change is real and occurring at an unprecedented rate. Among what makes climate change impacts on drylands more alarming is the large exposure of humans and their livelihoods (Megersa, *et al.,* 2019). Recurrent droughts and change in rainfall patterns are the major characteristics of the effects of climate change in the arid regions (Alemayehu, *et al.,* 2024; Ndiritu, 2024) where the inhabitants depend on natural resources and face severe drought impacts (FAO, 2019). Climate projections suggest rising climate risks in the livestock keeping regions due to limited adaptation capacity and less resilient production systems. The frequency and severity of droughts are expected to increase due to future climate change (Tamene, 2023), which will further increase severity in already affected areas (Lombe *et al.,* 2024).

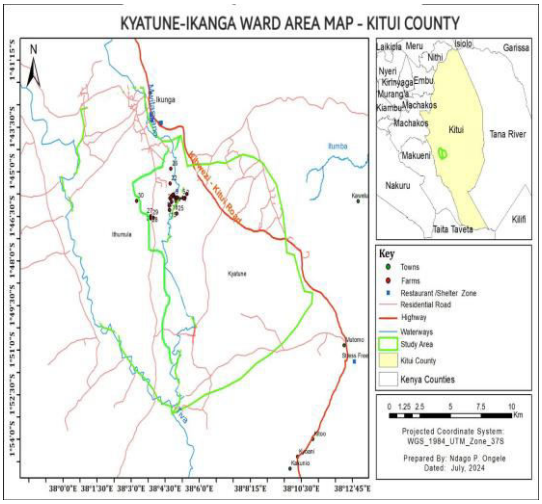
Climate change-induced droughts, erratic rainfall, and increasing temperatures have severely impacted livestock keeping, with the climatic shifts intensifying the vulnerability of the sector. Understanding the interconnected challenges is crucial for developing effective adaptation strategies that enhance livelihoods, promote sustainable resource management, and mitigate climate-induced conflicts in the semi-arid regions. This study was conducted in the in the semi-arid Kyatune-Ikanga Ward of Kitui County in Kenya. A major novelty of the study was that it not only assessed livestock keepers' adaptation and coping strategies but also explored the casual relationship between the temporal characteristics of drought with livestock market dynamics. Specifically, the objectives of the study were to (i) characterize drought occurrences, (ii) assess the impacts of drought on livestock, (iii) determine the associations between drought incidences and livestock market dynamics, (iv) establish the existing and potential adaptation and coping strategies and (v) discern the challenges in adaptation measures and latent solutions. The results of the study are aimed to contribute to filling existing knowledge gaps by providing insights into how livestock keepers in the semi-arid regions adapt to climate-induced shocks, informing policies and interventions that enhance sustainable livestock related land use security in vulnerable regions. The derived insights and strategies provides a valuable guide for policymakers, researchers, and practitioners working towards sustainable livestock arrangements in the face of climate variability. Moreover, it can also assist the government and stakeholders in the semi-arid livestock keeping in disaster risk management and policy formulation and enactment in the development of appropriate climate and gender responsive policies, adaptation, and mitigation strategies to build drought-resilient semi-arid land societies.

2.0 Materials and Methods

2.1 Study Area

The study was carried out in the Kyatune-Ikanga Ward area, which is located in the southern part of Kitui County, Kenya (Figure 1). The area was selected because of its semi-aridity and housing agro-pastoralism. Communities in the area are vulnerable to climatic change and weather vagaries. Therefore, their struggles with the drought and adaptation strategies were envisaged to provide appropriate insights on the levels of vulnerability and response characteristics. The rangeland consists of herbaceous vegetation as the dominant vegetation. The Ward covers an area of about 492 km^2 inhabited by about 50,000 people. The major land use is agro-pastoralism. Livestock is an important part of the Kyatune-Ikanga Ward agricultural system since most of the inhabitant population have livestock as a livelihood. Its production is dominated by traditional production systems characterized by continuous grazing in individually owned land.

Fig.1 Location of the Study Area (Source: Ndago, 2024)



Prominently grazed livestock include cattle, sheep, goats, chicken, ducks, and donkeys. Almost all the food consumed by the inhabitant population comes from limited food crops such as maize, beans, millet, sorghum, cassava and green grams. The Kyatune-Ikanga ward experiences socio-economic drought because the water scarcity affects both the demand and supply of economic goods, reaping severe social and economic consequences.

Resultant abiotic stresses, water and soil salinity, high temperatures and nutrient stress characterize the region, resulting in significant yield reductions of livestock and livestock feeds and staple foods for people. The majority of the energy required by the livestock for growth and maintenance is obtained from pastures and fodder crops, agricultural by-products, and crop wastes. Both non-legume and legume fodder crops are widely cultivated which supplement the nutrients needed for optimal livestock performance, including protein, vitamins, minerals, fibre, and water.

Other than drought, the wellbeing of the composition, quality, and quantity of livestock food in the Kyatune-Ikanga Ward are also impacted by floods, extreme heat or cold, humidity, and wind. The first phase of the drought cycle is established by a prolonged period of lack of precipitation. The situation gradually leads to narrowed moisture content in the soil which affects the growth of crops and grasslands, reducing the availability of food for livestock and people. The succeeding phase is falling water levels in rivers, reservoirs and aquifers which impact negatively on the supply of water for livestock, human and crop farming.

2.2 Data Collection and Analysis

A combination of a qualitative and quantitative research approach was employed to gather data and carry out analysis on the prevailing situation and strategies in livestock development, management and adaptation strategies of the Kyatune-Ikanga Ward agro-pastoralists to drought. The data were collected using a semi-structured questionnaire consisting of open-ended, multiple-choice, and paired-choice questions. A pilot test was conducted with local research assistants prior to the main study. The pilot test helped refine the final questionnaire by identifying unclear or ambiguous questions, ensuring logical flow, and improving clarity based on respondent feedback. The final questions were revised based on the research assistants' feedback and analysis of informants' responses to the questions.

The key variables measured in the study included socio-economic indicators such as gender, education level, age, household size, agricultural activities, non-farm income, access to extension services, land ownership, and livestock holdings), climate-related factors including access to weather information and exposure to drought), and coping and adaptation strategies such as livestock diversification, mobility, supplementary feeding, and reliance on social networks. In addition, data were collected on the impact of the drought and the adaptation strategies of households. To avoid misunderstandings, the interviews and discussions were conducted in the local language (Kamba) in liaison with Kiwahili, which the respondents could fully understand. The household surveys were complemented by nine focus group

discussions (FGDs) (three in each sub-location). Participants in the FGDs were mainly older people who could remember drought events. Therefore, FGD participants were purposely selected who had lived in the location for at least four decades, including older women, and who were willing to fully engage in a group discussion. The collected data were analyzed using descriptive statistics. Data translation and interpretation were managed to ensure consistency and accuracy.

3.0 Results and Discussion

3.1 Objective One: to characterize drought occurrences

a) Drought Characteristics and Trends

Analysis of drought implications to the livestock livelihood among the agro-pastoralists and the consequent impacts indicate that the study area experiences frequent droughts, some of them being extreme. Over 80% of the study participants report experiencing significant changes in climate patterns, including unpredictable rainfall and rising temperatures. They add that the climatic shifts lead to severe pasture and water shortages, negatively affecting livestock production and household incomes. The study computed the 12-month SPI to examine dry conditions in the study area from 1982 to 2022, revealing that 19 drought years occurred in the zone during the period. Based on the SPI results, extreme drought incidences were observed in 1985, 2000, and 2011. Two severe droughts were in 1984 and 2001 while five moderate ones occurred in 1992, 1994, 2010, 2015, and 2017. Temperature-driven evapotranspiration were observed to play a significant role in modulating drought severity. The SPI analysis also showed that the frequency of extreme drought events has increased over the past two decades, with several drought events occurring every two years since 2014. Furthermore, the analysis shows that the intensity of drought events in the most recent decade is higher than drought events of earlier decades. The area has experienced a drought event every 1–2 years for the last two decades whereas a previous drought happened once every 8 years. It is also observed that the occurrence of drought is due to high rainfall variability while the incidence of drought was due to the erratic behavior and unreliable distribution of rainfall.

97% of the respondents present drought as the most significant challenge to sustainable livestock farming in the Kyatune-Ikanga Ward. The increasing incidences of droughts have far-reaching implications for social and economic conditions as they lead to reduced livestock productivity and low crop yields. About 96% of the respondents report droughts to impact water resources by contributing to reducing streamflow, lowering water tables, deteriorating the water quality and diminishing reservoir levels. The shortages result in increased costs for water supply, reduction in livestock output and exacerbated food insecurity. 65% of households indicate consequently experiencing conflicts over scarce water and pasture resources due to competing demands. Lowered household incomes and insecurities lead to higher incidences of health issues on livestock and people. Analysis reveals 70% of the households to have experienced emergence of particular diseases and plants that cause harm to livestock. The episodes deteriorate livestock weight, market values and even death.

3.2 Objective Two: to assess the impacts of drought on livestock

a) Existing Livestock System

Livestock species commonly found in the Kyatune-Ikanga Ward include cattle, donkeys, goats, sheep, chicken and turkeys. Ducks, turkeys, rabbits and doves have been tried but with little success. The systems in which these species are kept vary, their characteristics ranging from small to large, extensive to intensive, traditional to industrial, mobile to sedentary, and mixed livestock species or mixed crops and livestock to specialize. Semi-intensive mixed system exists with 70% of the farmers having less than 5 traditional cattle. Some of the famers keep only bulls for plowing. Dairy goats are not kept because of lack of knowledge on how to develop and manage them. Exotic cattle breeds are rare with less than 1% of the inhabitants having them. Sustaining the exotic breeds is characterized by a combination of improved grazing (pasture on-farm), crop residues, and imported concentrate feed. Both systems provide milk both for home consumption and income from sales to local markets. Poultry is dominated by traditional chicks which are kept in the range.

The agro-pastoralists actively collect, store, treat and use livestock manure on their land parcels as a determinant of crop productivity, including spreading on pastures. The mixed crop-livestock systems are able to recycle manure as fertilizer for crop production on-farm, returning valuable nutrients and organic matter to the soil

and reducing the need for chemical fertilizers. The manure plays an important role in the long-term resilience of crop farming and livestock systems by enhancing soil capacity to absorb and retain water in the face of dry conditions.

The herd structure and size over time are indicated by 75% of the respondents to be an important determinant of the livestock system's productivity. In addition to livestock yields, the productivity system is linked to the number of productive versus unproductive animals within the herd at a given point in time. This is determined by factors such as animal fertility rates, the lengths of reproduction and maturation periods, and mortality rates, which vary significantly according to management practices as well as to the natural lifecycle of the species and breed. Dairy cattle age at first calving is 4.1 years versus 1.5 years for sheep age at first lambing and 168 days for backyard chicken age at first egg production (FAO, 2018). Managing the herd structure over time to reduce the breeding overhead, or the proportion of the total herd allocated to breeding as opposed to production is thus a common productivity intervention. For species with longer cycles, such as cattle, a lag time of several years may occur between the onset and impacts of such management practices. Resilience to climate change is also strongly linked to herd dynamics, with herders maintaining a certain size of animals as a way to store financial assets. 35% of the households keep bulls solely for cultivation and prefer to either milk the goats or buy milk for household consumption. In the face of drought, 20% of livestock producers protect a core reproductive herd by early destocking of non-breeding animals for sale before drought impacts manifest and prices.

In contrast, producers with smaller herds or with fewer non-breeding animals resort to selling breeding animals in times of crisis to meet immediate household needs, thereby limiting the future potential of the herd to grow and recover to the previous herd size. 25% of chicken producers easily pause and resume production in response to climate impacts, without losing the birds.

Shorter-cycle species with larger litters may also require less time to rebuild herds after a climate shock, in contrast to cattle herds which require years to rebuild due to their longer reproduction cycles and smaller litters. In addition to the output loss resulting from a shock, the time required to recover to previous output levels is a critical aspect of resilience.

Herd dynamics link to livestock sustainability due to the significance of herd size and growth for mitigation and other environmental objectives. On the one hand, increasing livestock productivity is often cited as synergistic with sustainability objectives due to the fact that increasing the efficiency of production generally lowers the intensity of environmental impact, land, water, or other natural resources associated with each unit of production output. Garnett *et al.,* (2014) informs that a highly efficient system with a large herd size may still generate an absolute volume of impact that exceeds thresholds for climate and natural resource tipping points Moreover, greater production efficiency and the increased profitability that may follow can incentivize producers to scale up and increase the size of the herd, eventually resulting in a higher overall environmental impact.

b) Impact of drought on livestock production

The study findings show that the influence of drought on livestock production and management is profound and multifaceted. The climatic adversity drastically reduces the availability of water, pastures and forage which are fundamental elements in livestock nutrition. The scarcity of water aggravates the situation, compromising the hydration and health of the animals. As a direct consequence, outputs are significantly affected. The reduced reproductive capacity of livestock and prolonged stress have long-term effects on the profitability and sustainability of livestock operations. In addition, the drought also impacts the economic management of livestock farms. Rising supplemental feed costs and the need for investments in water storage and distribution systems represent significant financial burdens on livestock keepers.

Out of the 41 agro-pastoralists interviewed, nearly all (98%) said they have suffered from the adverse effects of drought-induced water and pasture scarcity. Women in 60% of the households indicated having to travel over 10 km to access water during dry seasons. There were household incidents (15%) where boys and girls had to forfeit learning due to mobility for searching for water and alternative income sources during prolonged droughts. Close to 85% of the research participants pointed out that droughts strip the land of vegetation, leading to an increase in soil erosion and unrestricted water flow during rainfall. Continuous soil erosion has caused water pan and sand dam sources to become filled with silt.

Deaths of a large number of livestock were reported by all respondents. Furthermore, the agro-pastoralists experience a decrease in livestock sale prices, resulting in significant economic losses in drought times. Additionally, they (55%) face outbreaks of livestock diseases as well as challenges associated with long-distance livestock mobility (81%) in search of sufficient pasture and water.

During the focus group discussions, participants expressed concerns about the increasing severity of drought leading to degradation of rangeland and the replacement of palatable forages with non-palatable or invasive plants.

This scenario leads to a decrease in high-quality grazing plants on the range and a reduction in available forage. Additionally, the semi-arid inhabitants voiced their concerns about the degradation of dry-season grazing areas caused by frequent droughts and unpredictable rainfall patterns.

3.3 Objective Three: to determine the associations between drought incidences and livestock market dynamics

a) Impacts of Drought on Livestock Revenue

The impact of droughts on livestock prices has always been forced selling for extremely low prices just to survive, drastically cutting into their value.

With widespread famine, few people have cash to buy livestock, and the animals themselves get too weak to fetch good prices. Analysis of the relationship between livestock prices and drought severity from 1974 to 2017 show that livestock were sold at higher prices during the rainy season compared to the drought period (Table 1).

Table.1 Livestock Prices Fluctuations

Drought period		Price Prior to Drought		Price During Drought	
		Cattle	Goat	Cattle	Goat
1.	1974-1975	500	32	150	18
2.	1984-1987	2,500	25	1,200	15
3.	2007-2009	20,000	4,500	16,000	2,500
4.	2016-2017	35,000	7,000	24,000	4,000

FGDs affirmed that households had to sell livestock at a lower price during drought to buy livestock feed and drugs.

Long-term effects are manifested in household and community vulnerability which affect resilience. The results of the study revealed that drought had a significant negative impact on livestock value ($r = -2.68$, $p < 0.01$).

The scarcity of resources means fewer healthy animals, reducing the supply but also making the surviving ones worth far less, significantly impacting terms of trade of animal value.

The finding is consistent with other studies as they also found that livestock revenue declines during drought events because of decreases in rangeland productivity.

Reduced incomes jeopardizes the agropastoraoists adaptive capacity.

3.4 Objective Four: to establish the existing and potential adaptation and coping strategies

a) Diversification in Livestock Rearing

The survey brought to the fore that agro-pastoral households use several adaptation strategies to enhance their livestock resilience to drought. As part of livestock diversification, about 60% of the households change the composition of their herds as a key adaptation in response to recurrent droughts. Gender wise, the chi-square test results indicated no statistically significant difference between male and female-headed households, suggesting that both groups adopt similar strategies.

Indications of the study were that raising different types of livestock can be advantageous in financial and environmental terms. Basupi, *et al.,* (2019); Worku, (2024); Tamene *et al.,* (2023) and Kemal *et al.,* (2022) have similar findings for the arid and semi-arid lands

with Worku, (2024) adding that the diversity of livestock species enables households to utilize a broader array of ecological niches that includes the use of both grazing and browsing animals.

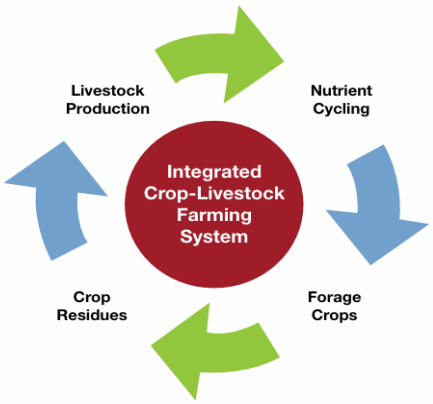
FGDs revealed that the past two decades have experienced diversification in livestock species due to changes in climate patterns and other influences. In the past, the Kamba community in the study area have had a livestock system relying solely on local breeds of cattle and goats. Drought-tolerant livestock such as the gala goat from northern Kenya have been adopted to upgrade the local breeds. Diversifying household herds with goats is informed by the animals' ability to tolerate drought effects and capacity to survive on browsing during feed shortages. Integrating small ruminants with larger animals is cited by 75% of respondents to be a key strategy for spreading risk and ensuring year-round productivity. However, 69% of respondents have it that inadequate capital is a significant constraint to achieving the adaptation strategy. This resonates with the findings of Menghistu *et al.,* (2020); Omollo *et al.,* (2018); and Adino & Ondiek, (2024) that limited resources is the major hindrance to livestock diversification.

b) Crop-livestock farming

60% of the households relate livestock keeping with crop cultivation, including the drought-tolerant ones. The farmers indicate the practice helps maximize resource use, providing both food for humans and feed for animals. The integrated crop-livestock system is reputed to be more sustainable as it allows for closed nutrient cycles, helping stabilize the farm ecosystem, significantly increasing the resilience and productivity of the agricultural system in the semi-arid areas. Livestock consume crop residues that would otherwise be wasted, and their manure is used to fertilize crops. Figure 2 shows the key aspects of an integrated crop-livestock farming system.

Based on the principle of enhancing natural biological processes above and below the ground, the integrated system represents a winning combination that reduces erosion, increases crop yields, raises soil biological activity and nutrient recycling, and intensifies land use that ensures households can increase the productivity of their farming systems.

Figure.2 Aspects of Integrated Crop-Livestock Farming System (Adapted from Antonio Rota *et al.,* (2009))



c) Rotational grazing

Deliberate rotational stocking is practiced by less than 5% of the households. However, about 65% of the households agree that the practice has capacity to improve soil health, enhances water retention, and helps manage vegetation. Livestock manure and urine are distributed more evenly across the pasture, acting as natural fertilizer and reducing nutrient concentration in specific areas, thereby improving overall soil fertility. Livestock extension experts advise farmers to take rotational grazing to increase the land's resilience to drought and pasture's ability to resist and recover from drought conditions compared to continuous grazing systems.

d) Herd Splitting

Dividing the livestock flock was found to be a coping strategy to drought for about 30% of the households.

Herds are divided into groups and sent to different locations during drought. The split herds are distributed to different relatives, friends, or to hired pasture lands so that they can graze separately. The division of herds depends on the availability of labor, the type and size of the herd, the health status of the livestock, and the availability of fodder in the region. Less productive but strong herds are sent to more distant areas while the pregnant females, more productive dairy cows, and young animals, on the other hand, are left closer to the homes.

e) Livelihoods Diversification

FGDs reiterate that encouraging non-livestock employment options can provide additional financial stability, allowing farmers to invest in sustainable livestock upkeep practices and better risk management. Policy and institutional support through the government and stakeholder programs can also provide financial support, access to credit and insurance, and extension services for enabling farmers to successfully transition to diversified systems. The 65% households with diversified livelihoods are indicated to demonstrate a higher capacity to adapt to environmental and economic changes, as they can reallocate resources and labor across different activities as needed.

The FGDs reported having experienced benefits from livelihood diversification as it provides significant benefits to livestock keepers by reducing vulnerability to climate shocks, enhancing household resilience, and stabilizing income streams. Diversification often involves engaging in activities that promote sustainable land use and the efficient management of natural resources, which are essential for long-term survival in semi-arid environments Added are the positive outcome of reduced risks as a result of diversifying income sources, such as engaging in crop farming, off-farm employment, or non-timber forest product harvesting all of which lessen reliance on livestock that are highly vulnerable to drought-induced feed and water shortage.

The alternative income streams buffer households against livestock losses and market fluctuations, ensuring a more consistent financial flow even during prolonged dry periods. A more stable income allows the livestock keepers to better manage risks, invest in improved livestock management practices, and recover more quickly from climate-related disaster. By diversifying activities, households can access a wider variety of food sources and use supplementary income to purchase food, which is crucial when livestock production is low.

f) Access to Water Strategies

56% of the households are for improving water harvesting and storage to augment water supplies and alleviate shortages in drought periods to help livestock keepers have crop varieties. Shallow wells and sand dams along the seasonal rivers and on farms, roof water harvesting and runoff collection for crops growth are increasingly becoming popular as a strategy for communities to prepare for and adapt to the challenges posed by increasing drought frequency and severity. Calls are brought forth to have extension personnel provide the right technical and management of water resources knowledge to the agropastoralists to avoid the failures. 85% of the people recommend attention to be paid by all stakeholders to sustainable exploitation of the water harvesting potential provided by the seasonal rivers,

3.5 Objective Five: to discern the challenges in adaptation strategies and latent solutions to droughts

Adaptation strategies to droughts face significant roadblocks, primarily driven by the complexities of drought, absence of appropriate planning for drought, inadequate value addition to livestock and related agricultural products and, existing weaknesses in extension services. Added, the barriers are driven by financial gaps, limited access to technology, and poor infrastructures. The barriers are compounded by poverty, lack of awareness, weak institutional capacity, low access to technology, and poor infrastructure.

a) Complexities of Drought

Droughts extend beyond environmental disruptions, posing a complex network of challenges that deeply affect livestock, significantly impacting their health and survival. In light of this, the options for long-term management strategies are identified to be constrained by various social, economic, and political changes as well as rangeland ecological conditions. The recurrence of droughts, leading to crises, underscores the urgency for robust and proactive interventions (Gizaw & Gan, 2017).

The anticipated increase in drought frequency and intensity, with implications for forage and water security

and potential conflict escalation, demands immediate attention to rainfall pattern deviations and resource competition (Mack, *et al.,* 2021). The narrative is further humanized by the experiences of persistent drought conditions which often force families into desperate searches for their needs, showcasing the urgent need for effective mitigation and adaptation strategies (Amnesty International (2021); Thomas *et al.,* 2020) all which have an effect on the livestock sector. Cognizance is identifying and mitigating conducive drought impacts is critical, demanding adaptation strategies in a changing climatic landscape (Luetkemeier *et al.,* 2017). This necessitates a nuanced understanding of the phenomenon and the diverse coping strategies employed by affected communities (Quandt, 2021). The insidious nature of drought transcending simple water scarcity to include the imbalance between demand and supply highlights the need for a comprehensive understanding of its impacts. As Wilhite suggests, effective drought management requires considering the long-term balance between precipitation and evapotranspiration, emphasizing the importance of integrated water resource management strategies (Wilhite, 2000).

Beyond physical and economic distress, droughts significantly impact the psychological well-being of individuals (Deglon, *et al.,* 2023). These challenges have long-term household, societal and intergenerational implications that underscore the complex nature of drought (Seka *et al.,* 2022) which acts as a catalyst for socio-economic disasters, magnified by the semi-arid region's vulnerability to climate change. This intensifies the adverse effects on livestock production, water resources, and livelihoods (Lottering *et al.,* 2020), with economic and social ramifications manifesting in survival strategies that amplify the severe consequences of inadequate response mechanisms (Treibich *et al.,* 2022).

b) Inapposite Planning for Drought

In all the households, there exists no systematic process of preparing for, responding to, and recovering from droughts exists. Planning would invite identifying potential drought risks and impacts, and developing appropriate measures to mitigate the consequences on vulnerable people and their livelihoods. Evidenced is involuntarily small scale stocking of some feed either in trees or farm stores. 75% of the respondents recommend participatory community training on preparedness and action-taking, with 62% advocating for development of concerted emergency and contingency plans by the government and stakeholders that factor the local people in the national and county government budgets to mitigate the negative impacts of drought on livestock operations to not only prepare producers to face climate crises, but also protect the well-being of livestock and long-term sustainability.

c) Deficiencies in Value Additions

Challenges to livestock value additions in the semi-arid areas include infrastructure gaps characterized by lack of proper infrastructures, appropriate knowledge and skills, technology access and deficits in marketing. Climate change exacerbates feed and water scarcity, impacting raw product quality and quantity, making the livestock sector more prone to drought vulnerability. About 70% of households counsel towards a value chain approach of the livestock sector for a more profitable, sustainable, and resilient to climate shocks. They add that sustainability is hinged on capacity building where training of farmers and processors in modern techniques is emphasized.

d) Weakened Livestock Extension Survives

The study established that livestock extension services in the semi-arid areas are often weak, inadequate and face significant challenges. These weaknesses are a major contributing factor to low livestock productivity and the vulnerability of agropastoral communities, especially in the face of climate change and frequent droughts. Extension services often suffer from insufficient financial resources, leading to understaffing, lack of transport to reach remote areas, and limited training for personnel (Table 2).

The vast, remote nature of the semi-arid lands, coupled with poor infrastructure like roads and communication networks, makes it difficult for extension officers to cover all areas and maintain regular contact with livestock farmers. At the same time, there are often weak linkages between research institutions and extension services, resulting in a lack of tailored, practical, and location-specific information and technology that addresses the unique challenges of the semi-arid environments. The extension services personnel may lack sufficient specialized training and technical know-how related to resilient livestock management practices in the semi-arid lands such as pasture management, water harvesting and disease control.

Table.2 Causes of Weakened Extension Services

Reason		[N=8]
1.	Inadequate Funding and Resources	8
2.	Logistical Challenges	5
3.	Information and Technology Gaps	7
4.	Human Resource Issues	4
5.	Socio-Cultural Barriers	3
6.	Policy and Institutional Gaps	6

The consequences of the weak livestock extension services exacerbate existing problems such as increased livestock losses during droughts due to poor health, nutrition, and unorganized husbandry practices.

4.0 Conclusion and Recommendations

Effective drought management strategies characterized by proactive planning are critical to sustain livestock as a livelihood in semi-arid areas. The strategies must be multifaceted, combining immediate and long-term resilience-building efforts that appreciate multi-stakeholder approach. By embracing drought-resistant crop varieties and optimizing water harvesting, farmers can maintain crop yields even during periods of reduced precipitation. Appreciating the advantages of the early warning systems and educating the public on the applying essences can play a crucial role in drought preparedness and response. Continuous monitoring of environmental conditions will provide critical data that can enhance the accuracy in predicting the onset, duration, and severity of droughts and the consequent enablement of taking appropriate proactive measures. Policy and institutional measures are essential to support the implementation of effective drought management strategies that can sustain the livestock sector through enhancement of adoption of drought-resilient practices that encourage research and extension services. Integration of indigenous knowledge with scientific approaches offers a promising pathway to sustainable livestock development and management.

4.1 Conflict of Interest

The authors declare no competing interests.

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