

Article

Integrating Socioeconomic and Community-Based Strategies for Drought Resilience in West Pokot, Kenya

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Abstract

This paper examines how demographic characteristics, institutional structures, and livelihood strategies shape household resilience to climate variability and drought in West Pokot County, one of Kenya's most climate-vulnerable arid and semi-arid lands (ASALs). Using a mixed-methods approach, it combines household survey data with three statistical techniques: Multinomial Logistic Regression (MLR) assesses the influence of gender, age, and education on livestock ownership and livelihood choices; Multiple Correspondence Analysis (MCA) reveals patterns in institutional access and adaptive practices; and Stepwise Linear Regression (SLR) quantifies the relationship between resilience strategies and agricultural productivity. Findings show that demographic factors, particularly gender and education, along with access to veterinary services, drought-tolerant inputs, and community-based organizations, significantly shape resilience. However, trade-offs exist: strategies improving livestock productivity may reduce crop yields due to resource and labor competition. This study recommends targeted interventions, including gender-responsive extension services, integration of indigenous and scientific knowledge, improved infrastructure, and participatory governance. These measures are vital for strengthening resilience not only in West Pokot but also in other drought-prone ASAL regions across sub-Saharan Africa.

Keywords: drought impacts; community resilience; multinomial logistic regression; Multiple Correspondence Analysis; linear regression; West Pokot; Kenya



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1. Introduction

Climate variability and change are among the most pressing global challenges, particularly for regions in the Global South, where livelihoods depend heavily on climate-sensitive sectors. As noted by the IPCC [1], Africa faces heightened exposure to climate-induced risks, with impacts disproportionately affecting food systems, water resources, and rural livelihoods. In regions reliant on rain-fed agriculture, such as much of sub-Saharan Africa, changes in rainfall patterns, increased frequency of droughts, and temperature extremes

are undermining food security and sustainable development [2,3]. Smallholder farming systems, which form the backbone of African agriculture, are particularly vulnerable due to limited adaptive capacity, socioeconomic constraints, and infrastructural deficits [4]. These realities call for urgent, locally grounded approaches to climate resilience that recognize the diversity of challenges and responses within vulnerable agro-ecological contexts.

Climate resilience, as defined in the Intergovernmental Panel on Climate Change (IPCC) framework, refers to the capacity of social, economic, and environmental systems to absorb climate shocks, reorganize, and maintain essential functions while adapting to longer-term climatic trends [5]. In African dryland contexts, such as Kenya's arid and semi-arid lands (ASALs), climate resilience is inherently shaped by ecological fragility, infrastructural deficits, and socio-political marginalization. It is thus critical to evaluate how resilience manifests in such systems, particularly through community-led adaptation efforts, and how it can be enhanced through integrated strategies that combine traditional knowledge and scientific forecasting.

West Pokot County in northwestern Kenya provides a compelling lens for examining these dynamics. Located in one of Kenya's most climate-vulnerable ASAL regions, West Pokot frequently experiences prolonged droughts, erratic rainfall, flash floods, and land degradation [5]. The local population, largely dependent on agro-pastoral and pastoral livelihoods, faces escalating climate risks that threaten food security, disrupt social structures, and undermine long-term development. Despite these challenges, West Pokot communities continue to draw on a rich repertoire of indigenous resilience practices, including seasonal mobility, livestock diversification, and community-based drought prediction methods [6].

These locally embedded practices are grounded in traditional ecological knowledge and maintained through social networks and cultural institutions. Phenological indicators, such as shifts in animal behavior, bird migration patterns, and plant cycles, serve as early signals of environmental change. Celestial observations, oral traditions, and rainmaking rituals further reinforce community readiness and collective agency [7,8]. Together, these strategies represent not only functional coping mechanisms but also a form of social capital that enhances climate resilience.

However, the increasing severity, frequency, and unpredictability of climate events demand new frameworks for understanding and supporting community resilience. Yao et al. [9] argue that resilience should be measured not just by exposure to climatic stress but by the speed and sustainability of recovery, especially in regions where climate shocks are recurrent. Similarly, Nasrnia and Ashktorab [10] emphasize the value of the Sustainable Livelihood Framework in mapping household resilience across socio-ecological contexts.

Building on this foundation, this study moves beyond generalized narratives of vulnerability in ASALs and instead foregrounds the role of endogenous knowledge systems, diversified livelihood strategies, and socioeconomic traits in shaping resilience. As Skogseid [11] and ActionAid Kenya et al. [12] highlight, community resilience is not merely reactive but includes proactive investments in social cohesion, spatial mobility, and adaptive decision-making. Moreover, Ogutu et al. [13] underscore the need to address structural inequalities, such as gender disparities and limited youth engagement, that constrain local adaptive capacity.

Infrastructure and institutional access also play a pivotal role in climate resilience. Spatially uneven access to markets, climate information, and agricultural extension services significantly affects households' ability to adopt resilient practices like drought-tolerant seeds, soil conservation, and early warning systems [14]. Women-headed households and youth, often concentrated in peripheral or resource-scarce zones, face compounded risks due to structural barriers in land tenure and participation [15,16].

The urgency of strengthening climate resilience is further underscored by the scale of recent climatic shocks across East Africa. More than 11.5 million people across Kenya, Uganda, and Tanzania have been affected by the region's worst food security crisis in two decades, with Kenya alone reporting over 3.5 million people in acute food insecurity, especially in ASAL counties like West Pokot [17,18]. Crop failures, livestock losses, and locust invasions have deepened poverty and exacerbated displacement, with households resorting to distress strategies such as selling productive assets or migrating across the border to Uganda [19–22].

Yet, resilience also hinges on environmental systems, such as water infrastructure and land regeneration, that interact with human systems. Thomas et al. [23] demonstrate how integrating digital tools like remote sensing and groundwater monitoring can enhance anticipatory governance, while Chen et al. [24] show that adaptive reservoir management supports both ecological and agricultural resilience under extreme climate scenarios.

Against this backdrop, community-based resilience strategies have gained renewed attention as vital levers for navigating climate uncertainty. In contexts like West Pokot, where formal state support is often insufficient, these grassroots systems remain essential for protecting livelihoods, ecosystems, and cultural identity. Nevertheless, empirical literature that bridges the intersection of climate shocks, socioeconomic vulnerability, and local adaptation, especially in marginalized drylands, remains limited.

This study addresses that gap by examining the multi-dimensional nature of resilience in West Pokot. It explores how socioeconomic characteristics, agricultural practices, and local knowledge systems interact to shape community resilience. Through a mixed-methods approach combining household surveys, geospatial mapping, and statistical modeling, including Multinomial Logistic Regression (MLR), Multiple Correspondence Analysis (MCA), and Simple Linear Regression (SLR), the research generates new insights into climate resilience pathways.

Ultimately, this study aims to inform adaptive policy design and programmatic interventions in drought-prone regions of sub-Saharan Africa. By centering community voices and localized strategies, it contributes to more inclusive, effective, and sustainable approaches to building climate resilience in vulnerable rural settings.

2. Study Framework and Methodology

To assess how community resilience, socioeconomic factors, and environmental stressors shape drought outcomes, we adopted a stepwise and integrated approach. Section 2.1 defines the study area and context. Section 2.2 details data sources, sampling, and validation procedures. Section 2.3 presents the statistical methods: Multinomial Logistic Regression (MLR) to identify key determinants, Multiple Correspondence Analysis (MCA) to explore categorical patterns, and Simple Linear Regression (SLR) to link resilience scores with outputs. This sequential approach ensures that each method addresses a specific aspect of the research question, while their integration provides a comprehensive and coherent understanding of drought resilience in West Pokot.

2.1. Study Area

West Pokot County, located in northwestern Kenya, comprises diverse agro-ecological zones characterized by pastoral, agro-pastoral, and mixed farming systems. The county is administratively divided into four sub-counties: West Pokot (Kapenguria), North Pokot (Kacheliba), Central Pokot (Sigor), and South Pokot (Chepareria). These areas are frequently affected by climatic shocks, especially droughts, which severely affect agricultural productivity and community livelihoods. This study targeted two sub-counties, Kacheliba and Sigor as a project area (please see Figure 1).

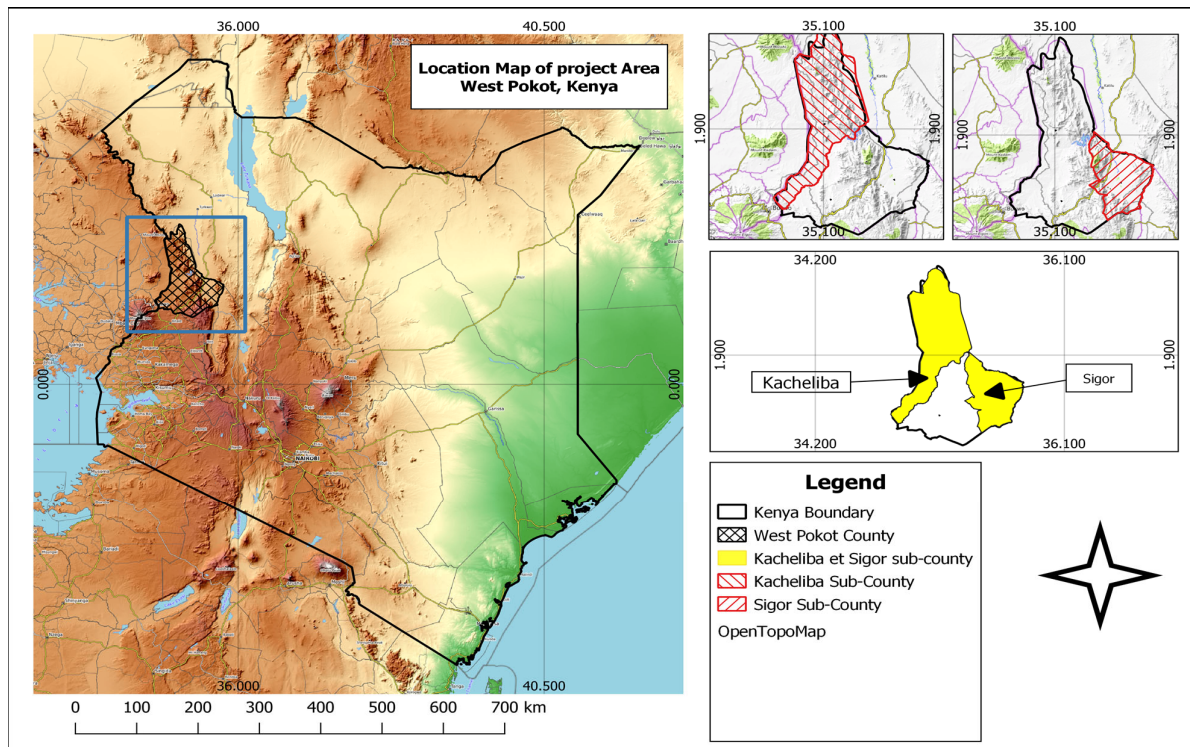


Figure 1. Location Map of project Kacheliba and Sigor, West Pokot County, Kenya [25].

The Pokot community, which constitutes most of the population, has a rich tradition of land classification based on altitude, rainfall, and agricultural potential. Kacheliba and Sigor sub-counties fall under the “Tow” classification, indicative of low agricultural potential and reliance on livestock-based livelihoods. Rainfall patterns vary significantly across the sub-counties, ranging from 250 mm in the arid lowlands of Kacheliba to 1200 mm in the higher elevations of Sigor, with two primary rainy seasons annually [26].

According to the 2019 national census, Kacheliba and Sigor host populations of approximately 133,505 and 119,016 residents, respectively [27]. These communities primarily engage in livestock rearing and subsistence farming, cultivating drought-resistant crops such as sorghum, maize, and millet. Livestock, particularly goats, sheep, cattle, and camels—are not only economic assets but also carry significant cultural value within the Pokot community [28,29].

Climate Vulnerability Assessment of West Pokot County

West Pokot County, situated in the northwestern arid and semi-arid region of Kenya, is among the country’s most climate-vulnerable counties due to a convergence of environmental exposure, socioeconomic fragility, and institutional limitations [30,31]. The region faces a complex interplay of risks, with climate variability and change significantly affecting local livelihoods, ecological systems, and human well-being.

The county is increasingly exposed to recurrent and intensifying climate hazards, particularly droughts, flash floods, and erratic rainfall. These events disrupt critical livelihood activities such as livestock rearing and crop farming, and strain already limited water resources. Rising temperatures and reduced vegetation cover have led to accelerated evapotranspiration, further diminishing soil moisture retention and contributing to desertification and land degradation [32,33]. Pasture regeneration and access to clean water have become less predictable, directly threatening food and livelihood security in the region.

The population of West Pokot is highly dependent on climate-sensitive sectors, notably rain-fed agriculture and pastoralism. With over 80% of households relying on livestock

or subsistence farming, even minor climatic shifts can have devastating consequences. The degradation of rangelands and the continued encroachment into marginal lands exacerbate vulnerability by diminishing the capacity of ecosystems to buffer climatic extremes [34]. Limited crop diversity and reliance on seasonal rainfall make household economies extremely sensitive to inter-annual climate fluctuations.

The county's capacity to adapt to climatic stress remains weak due to chronic underinvestment in infrastructure, education, and social services. Many communities lack access to all-weather roads, health facilities, irrigation schemes, and reliable extension services. Poverty levels remain high, particularly in remote sub-counties such as Kacheliba and Sigor, further constraining access to credit, insurance, and alternative livelihoods [35]. Vulnerable groups, particularly women and youth, face structural barriers in accessing resources, decision-making platforms, and climate information, undermining inclusive adaptation processes [36,37].

The intersection of climate shocks with food system fragility has led to persistent food insecurity and undernutrition. Drought-related crop failures and reduced milk production directly impair household dietary intake and child nutrition outcomes. Repeated climatic stress has strained coping mechanisms, leaving many households unable to recover between events and deepening vulnerability over time [38].

Climate variability has also exacerbated tensions over natural resources, particularly between pastoral communities along the Kenya–Uganda border. Seasonal migrations in search of pasture and water have become more frequent and unpredictable, often triggering conflict over grazing rights and water access. The increase in cattle raiding and cross-border insecurity reflects the compounded pressures of environmental degradation and weak conflict resolution mechanisms [39].

Despite these challenges, the Pokot community maintains rich Indigenous Knowledge Systems that play a central role in climate adaptation and environmental management. Traditional drought indicators, such as phenological changes, livestock behavior, and spiritual rituals like rainmaking ceremonies, continue to inform local responses to climatic changes. Oral traditions, storytelling, and intergenerational transmission of knowledge serve as repositories of historical memory and adaptive practices [7,8]. However, these systems are increasingly threatened by modernization, erosion of cultural institutions, and exclusion from formal adaptation planning frameworks [40,41].

2.2. Data Sources and Sampling Procedures

A combined quantitative approach was employed to delve deeper into community challenges and their resilience to climate variability. This study further conducted a quantitative analysis involving surveys aimed at identifying the impacts of extreme and severe droughts on livelihoods, including agricultural productivity, water scarcity, and changes in pastoral practices. This approach provided a broad overview of the economic and social stresses these communities face during these periods. This methodological blend allows for the triangulation of quantitative insights with community-level observations, enhancing both the reliability and contextual relevance of the findings.

Quantitative (Surveys) Analysis

The survey was then designed, targeting farmers from areas affected by extreme and severe drought events. Its overarching goal is to offer a comprehensive understanding of the multifaceted dimensions of drought, spanning the climatic, socioeconomic, and meteorological realms.

Geographically, the survey zooms in on areas affected by extreme drought, specifically targeting the regions of Kacheliba and Sigor. These locations, previously identified through

remote sensing analyses and government drought vulnerability assessments, serve as microcosms of the broader challenges faced by communities grappling with erratic weather patterns and diminishing agricultural yields. The survey adopted a structured approach, leveraging closed-ended questions to systematically gather data across various domains. It encompasses inquiries into demographics, agricultural practices, livestock rearing, crop cultivation, water access, food security, and adaptive measures employed by farmers to withstand drought-induced adversities. The utilization of Kobo Collect as the survey platform ensures not only the efficiency of data collection but also stringent quality control measures to uphold the integrity and reliability of the findings [42]. To ensure community integration and involvement in this study, a community-based organization (CBO) and local members were trained on the use of Kobo Collect and deployed across the targeted areas. This participatory approach enhanced local ownership and improved the accuracy and acceptability of responses.

A total of 100 households were randomly reached for surveying in the affected zones of Sigor and Kacheliba, of which 88 were retained after data cleaning due to issues such as incomplete responses or inconsistencies. Despite the modest sample size, the targeted areas ensured sufficient representativeness to capture variations in drought impact and adaptive capacity. A stratified random sampling method was employed to ensure that each household in the study area had an equal chance of being selected. This stratification accounted for livelihood types (pastoralists, agro-pastoralists, and crop farmers), geographical characteristics (e.g., valley vs. highland zones), and exposure to drought risks.

To enhance local relevance and cultural sensitivity, community leaders and elders were consulted during the planning phase to help identify appropriate entry points, ensure community buy-in, and validate household lists. The sampling strategy was also guided by recent census data and local administrative boundaries, ensuring proportional representation across gender, age, and socioeconomic strata. Although the sample size ($n = 88$) is relatively small, it is consistent with similar studies in resource-constrained settings [43–46] and was sufficient to extract key patterns using descriptive and inferential statistical methods, including correlation and regression analysis.

The approach prioritized inclusivity, with deliberate efforts to reach marginalized populations, including women-headed households, persons with disabilities, and youth. This allowed for a nuanced analysis of community resilience strategies, capturing the intersection of vulnerability and agency in drought-prone regions. Overall, the survey provides a granular, context-sensitive dataset that contributes valuable insights into household-level adaptation dynamics in West Pokot County.

2.3. Data Processing and Statistical Analysis

2.3.1. Data Processing

The quantitative data were processed and analyzed using Python 3.12.4, with preprocessing conducted through Pandas and SciPy libraries. This included cleaning, handling missing values (via imputation and deletion), and outlier management through techniques such as z-scores and winsorization [42,47–49]. Data validation was also performed to ensure reliability, including triangulation with secondary sources where applicable [50,51].

The analytical framework involved descriptive statistics to capture demographic characteristics, farming activities, and drought impacts. Frequency analysis in Figure 2. It was revealed that mixed farming was predominant (81.4%), followed by livestock (12.8%) and crop-only farming (5.8%).

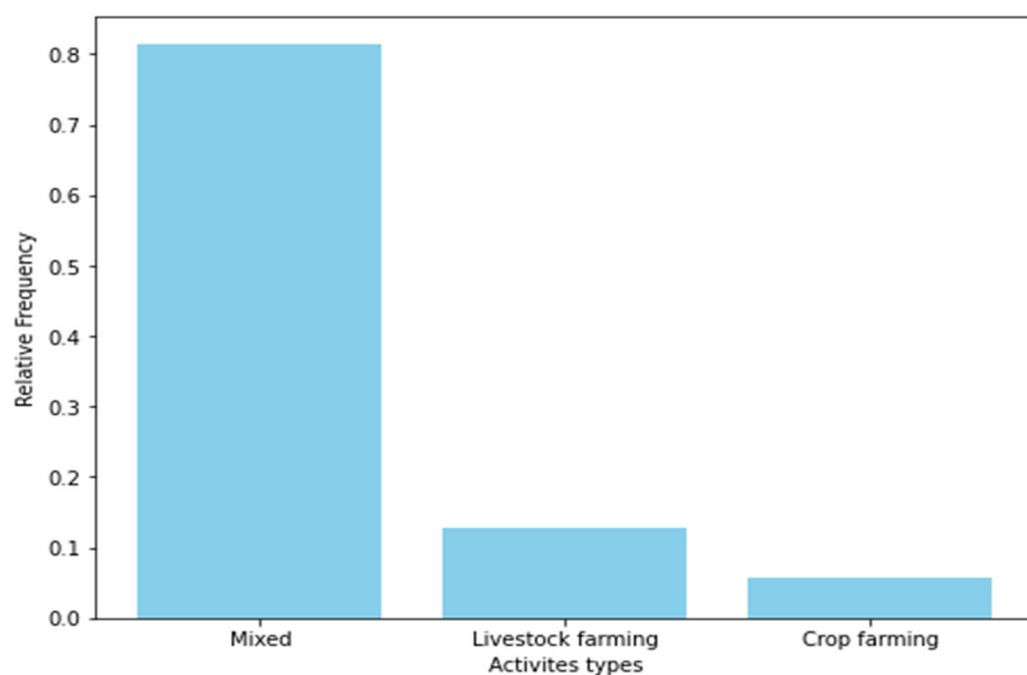


Figure 2. Distribution of households activity types.

Livestock distribution in Table 1 showed that goats (96%), camels (90%), and cows (72%) were most common, while maize (97%) and beans (73%) dominated crop production. The data also indicate a high diversity in livestock farming, with sheep accounting for 52% of livestock holdings. Each type of livestock serves various roles, from producing dairy and meat to holding cultural and financial significance.

Table 1. Frequency Distribution of Livestock Types Owned by Households.

Type	Frequencies
Cow	72
Goat	96
Sheep	52
Camel	90

Meanwhile, crop production in Table 2 had revealed Maize as the most common crops in both Kacheliba and Sigor. It makes up a large proportion of 97%, followed by Beans with 73%. Sorghum, that is commonly known for being drought resilient, is the least crop farming (51%) with higher frequency.

Table 2. Frequency Distribution of Crop Types Cultivated in Kacheliba and Sigor.

Type	Frequencies
Maize	97
Sorghum	51
Beans	73
Others	64

Given the nomadic nature of the Pokot community, the size of livestock herds is a critical piece of information that requires particular attention. The distribution of livestock herd sizes, as shown in Table 3, indicates a predominance of small-scale livestock farming,

with fewer medium and large-scale herders. This finding contradicts the estimates from Kimiti et al. [26], which reported an average herd size of around 117 live-stock units in nomadic areas and approximately 56 units in sedentary areas. The lower figures in the current data could be attributed to recurrent drought disasters, limited access to veterinary services, high vulnerability to diseases, and constrained resources, making smaller herds more sustainable for households.

Table 3. Distribution of Livestock Herd Sizes among Surveyed Households.

Interval	Frequencies
[1–49]	80.2
[50–99]	12.8
[100–149]	6.98

In West Pokot, Kenya, agricultural production relies heavily on community resilience strategies to cope with environmental and economic challenges. The most common practices, as shown in Table 4, include adopting modern agricultural techniques, utilizing diverse grazing areas, breeding resilient livestock, and diversifying income through business ventures. These strategies help ensure consistent productivity, financial stability, and resilience against agricultural risks. Literature such as Nyberg et al. [52] and Lolemtum et al. [53,54] discuss the adaptive strategies of pastoralists in West Pokot. These strategies include grazing management practices that involve moving livestock to various grazing areas to cope with environmental challenges such as drought and pasture scarcity. This method helps maintain pasture health and ensures that livestock have sufficient forage throughout the year.

Table 4. Adopted Community Resilience Strategies in Response to Climatic and Economic Shocks.

Type	Frequencies
I moved my livestock to greener areas	62
I practiced rotational farming for crops	4
I practiced different areas of grazing	94
I planted resilient crops	80
I moved to keep more resilient livestock	91
I sold a portion of my livestock	77
I embraced business	89
I started practicing modern agriculture	98
I cut the trees and feed my livestock	51

Understanding the distribution of age and gender in the agricultural workforce of West Pokot is crucial for designing effective interventions. By addressing the specific needs of different age groups and supporting both women and men, the agricultural sector in West Pokot can be made more productive, sustainable, and resilient. The gender disparity in agricultural practices shows a slight female predominance, with 53% being female and 47% male. Women’s contribution to the agricultural workforce in West Pokot is significant, playing a major role deeply embedded in Pokot culture. According to the Food and Agriculture Organization [55], women are integral to small-scale agriculture in developing countries, producing between 60% and 80% of the food. Despite their significant contributions, women often face greater challenges than men in accessing land, credit, and

productivity-enhancing inputs and services. While specific data for West Pokot County are limited, national and regional trends indicate that women constitute a substantial portion of the agricultural labor force in Kenya and beyond [56,57]. For instance, the Kenya National Climate Change Action Plan (NCCAP) 2023–2027 reports that women make up approximately 75% of the labor force in small-scale agriculture nationwide. However, they hold only about 10% of land titles and control merely 1.63% of agricultural land, highlighting significant gender disparities in land ownership and access to resources. These disparities underscore the importance of gender-sensitive policies and interventions to address systemic inequalities in land ownership and resource access, particularly in regions like West Pokot where agriculture is a primary livelihood. Culturally, women in West Pokot often engage in crop production near family households, while men are more involved in livestock farming, which typically takes place further from home, within a 10 km radius.

In the context of agricultural production in West Pokot, Kenya, the age distribution of the population in Table 5 provides insights into labor availability, productivity, and the community resilience against an escalating threat of climatic extremes. The age distribution in West Pokot's agricultural sector reveals a workforce with diverse age groups, each bringing different strengths and challenges. The presence of a large number of individuals in the 27–35 and 36–42 age intervals is a positive sign for current productivity. However, the relatively low number of young adults (18–26) suggests potential future labor shortages, likely due to the increased risk of agricultural losses. The significant number of older adults (50–80) highlights the importance of succession planning and the need to attract younger individuals to agriculture to sustain and advance the sector. These findings are consistent with broader demographic trends reported in the region. According to sources such as the Shawiza [58] and Boh [59], agricultural activities in West Pokot involve a diverse age range, with a noticeable engagement of both younger and older farmers. The studies highlight that such diversity is critical for sustaining agricultural productivity and resilience in the region.

Table 5. Age Group Distribution of Agricultural Household Respondents in West Pokot.

Interval	Age Distribution	Frequencies
[18–26]	Young Adults	12
[27–35]	Early Working Age	31
[36–42]	Middle-Aged Adults	22
[43–49]	Older Working Age	13
[50–80]	Senior Adults	22

Table 6 indicates that over half of the agricultural population in West Pokot lacks formal education. This finding aligns with reports from the Kenya Ministry of Agriculture, Livestock and Fisheries [60] and the West Pokot County Government [61], which state that only 31% of household heads have completed primary education, and just 8.8% have secondary education. Among female household heads, none reported receiving formal education. This educational deficit limits the adoption of modern agricultural practices and overall productivity [60]. Additionally, 20% of the agricultural population has some primary education but did not complete it, indicating a reliance on traditional farming methods passed through generations.

Overall, the diverse range of strategies employed by the community underscores the importance of adaptation in building resilience and mitigating the negative consequences of environmental stressors on their livelihoods.

Table 6. Educational Attainment Levels among Agricultural Households in West Pokot.

Category	Frequencies
No Education	54.65
Primary Incomplete	19.78
Primary Complete	9.31
Secondary Incomplete	5.81
Secondary Complete	5.81
University	4.66

2.3.2. Statistical Analysis

To analyze the complex relationships between community resilience, socioeconomic characteristics, and agricultural performance in drought-prone areas, we adopted a stepwise analytical framework combining three statistical methods:

- **Multinomial Logistic Regression (MLR):** Used to analyze the influence of socioeconomic factors (such as gender, education, age, and farming activity) on livestock production. MLR allowed us to determine which demographic and livelihood factors are significantly associated with variations in livestock outcomes.
- **Multiple Correspondence Analysis (MCA):** Applied to extract and summarize patterns from categorical variables across three aspects: livestock production, crop production, and community resilience. MCA was selected to reduce the dimensionality of categorical survey data and to reveal underlying structures and associations among resilience strategies and agricultural practices.
- **Simple Linear Regression (SLR):** Used to quantify the relationships between community resilience scores (derived from MCA) and agricultural outputs (livestock and crop production). SLR enabled us to measure the strength and direction of these relationships, providing insight into how resilience strategies impact productivity. The integration of these methods allows for a stepwise analysis: MLR identifies key socioeconomic determinants of livestock production; MCA distills complex categorical data into interpretable components; and SLR links these components to tangible agricultural outcomes. This division of labor ensures that each method addresses a specific aspect of the research question, while their combination provides a holistic understanding of drought resilience in West Pokot.

Socioeconomic Factors of Household Livestock Production

In drought-prone areas like Sigor and Kacheliba, these insights are crucial for understanding community resilience strategies. This study employed the Multinomial Logistic Regression (MLR) model, using the function ‘GLM ()’ in R, to analyze the data [62–64]. This model allows for the examination of multiple dependent outcomes influenced by various independent variables. Specifically, this model helps identify how different socioeconomic factors and agricultural activities impact livestock production and community resilience.

Generalized Linear Models (GLMs) are widely used to analyze various types of data in agriculture, providing flexibility to model different distributions and link functions suitable for the nature of agricultural data [62,63]. The ‘GLM ()’ function in R was used to fit the MLR model, defined as follows:

$$\log \frac{p}{1-p} = \beta_0 + \beta_1 \times \text{Gender} + \beta_2 \times \text{Age} + \beta_3 \times \text{Educational Level} + \beta_4 \times \text{Agricultural Activity} \quad (1)$$

where $p = P[Y = \text{'Yes'}]$ represents the probability of a given household head having a high quantity of livestock, based on the predictor variables included in this model.

Livestock Production, Community Resilience, and Crop Production

This study used Simple Linear Regression (SLR) models [64] to examine relationships between livestock and crop production, community resilience, and livestock production scores. SLR models are widely used in agricultural research to quantify how one variable influence another.

Smith and Jones [65] demonstrated that increased fertilizer application significantly improves crop yield using SLR models, illustrating SLR's utility in agricultural productivity studies. Brown et al. [66] found a strong linear relationship between feed quality and livestock weight gain, emphasizing SLR's applicability in livestock management. Johnson [67] linked community training programs to higher resilience scores, highlighting the role of education in enhancing community resilience. Williams et al. [68] showed that integrated farming systems boost farm productivity more than monoculture, supporting SLR's use in evaluating complex agricultural systems.

By applying SLR models, this study aimed to understand factors influencing livestock and crop production and community resilience, developing strategies to enhance agricultural outputs and food security in vulnerable areas.

Additionally, this study employed Multiple Correspondence Analysis (MCA) [69,70] to extract scores from categorical data related to livestock production, community resilience, and crop production. MCA, an extension of Principal Component Analysis (PCA) for categorical variables [71,72], was applied using the FactoMineR, ade4, and Factoshiny packages in R software 4.5.1. These models are defined as follows:

$$\text{Livestock production score} = \beta_0 + \beta_1 \times \text{community resilience score} + \epsilon \quad (2)$$

$$\text{Crop production score} = \beta_0 + \beta_1 \times \text{community resilience score} + \epsilon \quad (3)$$

where β_0 and β_1 represent the coefficients in the regression model, and ϵ represents the regression error.

3. Findings

This section synthesizes empirical evidence on how demographic characteristics, institutional dynamics, and livelihood strategies intersect to shape household resilience to climate variability in West Pokot, Kenya. Using a mixed-methods framework integrating Multinomial Logistic Regression (MLR), Multiple Correspondence Analysis (MCA), and Stepwise Linear Regression (SLR), we present key insights into how these dimensions affect agricultural productivity, particularly livestock and crop production, as proxies for resilience.

3.1. Demographic Factors and Household Resilience

The Multinomial Logistic Regression (MLR) model was employed to assess how socioeconomic characteristics, such as gender, education, age, and farming activity, affect livestock herd size at the household level. Model validation was performed using three performance metrics: the Likelihood Ratio Test (LRT), accuracy, and Nagelkerke's R^2 [62].

In this section, this study presents the results of the previously defined model. Firstly, the model evaluates predictive performance. To this end, this study computes three well-known measures: (1) The Likelihood Ratio Test (LRT), (2) accuracy, and (3) Nagelkerke's R^2 [62]. Table 7 shows that the MLR defined in (Equation (1)) model performs strongly, with:

Table 7. Performance Metrics for Multinomial Logistic Regression Model on Livestock Herd Size.

Metric	Value
LRT	$p\text{-Value} = 1.24 \times 10^{-8}$
Accuracy	0.93
Nagelkerke's R^2	0.96

The model evaluation metrics in Table 8 indicates the model high statistical significance. The high accuracy score of 93% demonstrates the model's strong predictive capability, suggesting that it can reliably predict the outcomes. Additionally, the high Nagelkerke's R^2 value of 0.96 indicates that the model explains the variability of the data very well, highlighting its strong predictive power. Findings from the MLR analysis (Table 8) demonstrate that demographic characteristics significantly influence livestock herd size, a critical determinant of resilience in arid and semi-arid regions.

Table 8. Influence of Socioeconomic Characteristics on Livestock Herd Size: MLR Coefficients and Significance Levels.

Characteristic	Coefficient	<i>p</i> -Value
<i>Gender</i>	-	-
Women	0.71	0.54
Men	3.10	0.04
<i>Education level</i>	-	-
No Education	1.32	0.03
Primary Incomplete	−0.42	0.99
Primary Complete	17.82	0.65
Secondary Incomplete	0.82	0.97
Secondary Complete	18.16	0.78
University	−3.81	0.02
<i>Age</i>	-	-
[18–26]	6.82	0.07
[27–35]	4.34	0.8
[36–42]	4.65	0.23
[43–49]	4.60	0.17
[50–80]	3.12	0.024
<i>Activity types</i>	-	-
Livestock farming	1.71	0.01
Agriculture farming	−0.013	0.54
Mixed	1.10	0.97

Table 8 provides detailed coefficients and *p*-values that reveal the statistical significance and direction of influence for key socioeconomic variables on livestock herd sizes.

Male-headed households are more likely to own medium-sized herds (50–99 animals), reflecting persistent gender disparities in access to livestock-related resources. University-educated respondents tend to manage smaller herds, implying occupational diversification beyond agriculture. Older household heads (aged 50–80) are associated with larger herd sizes, suggesting that life experience contributes to more effective resource and risk management. These results indicate that age, gender, and education not only determine access to productive assets but also shape the capacity of households to buffer against climatic shocks.

3.2. Institutional Structures and Agricultural Livelihoods

Building on socioeconomic analysis, this section explores the relationships between Institutional Structures and Agricultural Livelihoods, particularly in the domains of live-

stock production, community resilience, and crop farming. To uncover underlying patterns among categorical variables, Multiple Correspondence Analysis (MCA) was employed. This technique reduces data complexity by identifying key dimensions (principal components) that capture the most variation in responses [63–65]. While MCA itself is not a causal model, the dimensions it uncovers serve as meaningful constructs that correlate strongly with household-level resilience outcomes, as validated through triangulation with SLR models and descriptive indicators. Each dimension reflects a set of institutional or behavioral conditions that shape household responses to climate-related risks. This approach is consistent with resilience theory, which conceptualizes resilience as a function of access to assets, institutional support, adaptive capacity, and social capital.

In the MCA model for livestock productivity (Table 9), Dimension 1 (89.26%) reflects households with reliable access to veterinary care, drought-resilient livestock breeds, and agricultural extension services. These are all well-established predictors of livestock health and productivity in arid regions, as supported by resilience literature (e.g., [23]). As such, this dimension can be interpreted as a proxy for institutional resilience capacity in livestock systems. Dimension 2, which explains 7.76% of the variance, captures variance related to informal knowledge exchange and seasonal grazing management, reflecting adaptive practices embedded in traditional pastoralist systems. These behaviors contribute to resilience through mobility and ecological flexibility, two recognized traits of climate adaptation in pastoralist communities. Dimension 3, contributing 2.97% of the variance, relates to participation in NGO programs and insurance schemes, which, though less widespread, provide safety nets that improve recovery time after climatic shocks.

Table 9. Explained Variance in Livestock Productivity: MCA Eigenvalues by Dimension.

Components	Eigenvalue	% of Variance
Dimension 1 (Veterinary and Extension Access)	3.91	89.26
Dimension 2 (Informal Practices and Grazing Management)	0.34	7.76
Dimension 3 (NGO/External Program Influence)	0.13	2.97

In the MCA model assessing community resilience strategies below (Table 10), three key dimensions emerge. Dimension 1, which explains 70.39% of the total variance, captures households' engagement in collective support networks, including farmer cooperatives, women's groups, and traditional councils. These institutions play a pivotal role in facilitating resource sharing, knowledge exchange, and coordinated adaptation responses. Dimension 2, accounting for 16.67% of the variance, reflects livelihood diversification strategies, such as small-scale business ventures and seasonal migration, tactics often employed to reduce dependency on climate-sensitive income sources. Lastly, Dimension 3, which explains 12.94% of the variance, is associated with household-level coping mechanisms, including food storage, asset liquidation, and adjustments in consumption patterns. Together, these dimensions illustrate how resilience in West Pokot is shaped through a combination of social capital, economic flexibility, and domestic adaptation behaviors.

Table 10. Explained Variance in Community Resilience Strategies: MCA Eigenvalues by Dimension.

Components	Eigenvalue	% of Variance
Dimension 1 (Community Networks and Social Capital)	4.35	70.39
Dimension 2 (Livelihood Diversification)	1.03	16.67
Dimension 3 (Household Coping Strategies)	0.80	12.94

In the crop farming MCA model below (Table 11), Dimension 1 is overwhelmingly dominant, explaining 94.07% of the total variance. This dimension primarily encompasses institutional access to irrigation, drought-tolerant seeds, and participation in conservation agriculture. These practices are proven to directly reduce climate risk exposure and enhance agronomic resilience. Dimension 2, accounting for 5.46% of the variance, includes household-level innovations like composting or use of organic inputs, indicating micro-level adaptive capacity. Dimension 3, with only 0.47% of the variance, has minimal explanatory power and may capture outlier behaviors or niche practices not widely adopted across the surveyed population. This distribution underscores the central importance of institutional access and conservation practices in determining crop resilience in West Pokot.

Table 11. Explained Variance in Crop Production Strategies: MCA Eigenvalues by Dimension.

Components	Eigenvalue	% of Variance
Dimension 1 (Irrigation and Climate-Smart Inputs)	3.97	94.07
Dimension 2 (Household-Level Innovations)	0.23	5.46
Dimension 3 (Miscellaneous/Niche Practices)	0.02	0.47

The dimensions extracted through Multiple Correspondence Analysis (MCA) are not arbitrary statistical constructs but are thematically aligned with empirically validated determinants of resilience. Their relevance is further reinforced by the results of the Simple Linear Regression (SLR) models, which show that households corresponding to Dimension 1 in each domain consistently demonstrate higher productivity and stronger adaptive outcomes.

In the domain of livestock systems, access to veterinary services and the maintenance of larger herd sizes are both positively correlated with enhanced resilience. Regarding community resilience, households actively participating in community-based organizations (CBOs) and employing livelihood diversification strategies exhibit improved food security. In the area of crop production, access to climate-smart agricultural inputs, such as drought-tolerant seeds and irrigation infrastructure, is strongly associated with greater yield stability.

Taken together, these findings indicate that the MCA-derived dimensions represent valid proxies for core pillars of resilience, namely institutional support, social capital, and adaptive capacity. These pillars are well established in the resilience literature, including recent contributions from the IPCC [1], Nasrnia and Ashktorab [73], Thomas et al. [23], and Yao et al. [74].

3.3. Livelihood Strategies and Trade-Offs in Resilience

The predictive performance of the SLR models will evaluate the models defined in Equations (3) and (3). The predictive performance is assessed using accuracy and other relevant metrics to ensure the models reliably predict outcomes. The estimated Coefficients and Their *p*-values for the SLR models involve examining the significance of the coefficients to understand the influence of different variables on outcomes. These three metrics aim to provide a comprehensive evaluation of the model's effectiveness and predictive capability. The findings (Tables 12 and 13) reveals that resilience strategies, particularly livestock diversification, mobile grazing, and mixed-income generation, are shown to improve livestock productivity. However, these same strategies negatively correlate with crop productivity, suggesting a labor and resource trade-off between sectors. Households specializing in livestock farming report greater herd sizes but higher exposure to climate-induced risks, while those adopting crop diversification benefit from food security but face challenges in maintaining livestock output. These dynamics reflect the inherent "liveli-

hood compromise,” where prioritizing resilience in one domain may constrain outcomes in another.

Table 12. Coefficient of Determination (R^2) for SLR Models Evaluating Livelihood Productivity.

Models	R^2
Model (Equation (2))	0.79
Model (Equation (3))	0.86

Table 13. SLR Coefficients Linking Community Resilience to Agricultural Outcomes.

Model	Predicted Variable	Coefficient	p -Value
Model in (Equation (3))	Community resilience Score	$\beta_1 = 0.69$	0.00045
Model in (Equation (8))	Community resilience Score	$\beta_1 = -0.178$	0.000083

3.4. Integrated Pathways for Enhancing Resilience

These results highlight the complex interplay between livestock and crop production in shaping community resilience. Integrated approaches that balance both dimensions of agricultural livelihoods are crucial for enhancing overall sustainability. For example, promoting drought-resistant crops alongside sustainable livestock management practices can help communities diversify their income sources and reduce their vulnerability to climate-induced shocks. Additionally, strengthening community-based support networks and promoting access to resources can enhance adaptive capacity and build resilience to environmental stressors.

4. Discussion

This study presents a comprehensive analysis of the socioeconomic, agricultural, and environmental dimensions of drought resilience in West Pokot, Kenya. By integrating Multinomial Logistic Regression (MLR) analysis with qualitative insights from community-based observations, it provides a multi-layered understanding of how demographic characteristics, livelihood choices, and adaptive strategies shape household-level resilience to climate variability in arid and semi-arid lands (ASALs) [72]. These findings resonate with similar empirical studies from Ethiopia, Niger, and southern Zimbabwe, where multi-stressor environments necessitate diversified, adaptive responses across livelihood systems [75–77].

The MLR results show that gender, education, age, and livelihood specialization are key determinants of livestock herd size, a critical asset in pastoralist and agro-pastoralist economies. Male-headed households tend to have larger herds, which is consistent with findings from Ethiopia’s Borana zone and northern Tanzania, where patriarchal norms and gendered access to assets reinforce men’s dominance in livestock ownership [78,79]. The inverse association between university education and herd size reflects a broader transition toward off-farm employment and diversified income strategies, also observed in Burkina Faso and northern Ghana [80]. Meanwhile, the positive influence of age suggests that older farmers accumulate knowledge and assets over time, a trend supported by studies in Mozambique and Malawi, where experience enhances adaptive planning and risk perception [81,82]. However, households with a strong focus on livestock-only systems may face higher exposure to drought-induced losses, highlighting the vulnerability of non-diversified pastoralist economies, as shown in similar studies from southern Madagascar and the Sahel [83].

Community resilience strategies such as herd mobility, mixed-income strategies, and investment in drought-resilient assets demonstrate clear benefits for livestock productivity but come with trade-offs for crop production [57]. This reflects what Scoones [84] calls the

“livelihood compromise,” where coping strategies in one domain may reduce efficiency or investment in another. For instance, in southern Zimbabwe, the allocation of labor to mobile grazing during droughts was found to limit the availability of manpower for crop cultivation [85]. The findings from West Pokot affirm this tension and call for integrated adaptation frameworks that balance risk-spreading strategies without undermining cross-sectoral productivity.

In terms of policy implications, several critical priorities emerge. First is the need for gender-responsive resilience programming. Despite their central role in farming and household management, women in ASALs often lack secure land tenure, credit access, and representation in agricultural cooperatives, barriers also well documented in Senegal, Uganda, and Zambia [86,87]. Kenya’s National Policy on Gender and Development offers a promising foundation but must be operationalized at the county level through tailored, community-specific interventions that address entrenched gender disparities.

Second, extension services must be reimagined to support climate-smart agriculture (CSA). Current top-down approaches often fail to respond to local realities, especially in marginalized areas. The success of farmer field schools in Kenya, Uganda, and Tanzania shows the value of participatory extension models that combine experiential learning with scientific innovations [88]. Institutions like KALRO and CGIAR should continue to promote integrated farming models that blend livestock, crop, and ecological components, key for building both adaptive capacity and long-term productivity [89].

Third, this study reinforces the critical role of livelihood diversification in cushioning climate shocks. Households engaged in multiple income-generating activities, be it agro-processing, petty trade, or eco-tourism, display stronger economic resilience, a trend observed in studies from Tana River (Kenya), Karamoja (Uganda), and rural Rwanda [90,91]. National strategies such as Kenya’s Agricultural Sector Transformation and Growth Strategy (ASTGS) must therefore prioritize inclusive support for such diversified enterprises, including better access to microfinance, insurance, and market information.

Moreover, the analysis points to the value of community institutions and social capital in resilience-building. Farmer cooperatives, water user associations, and self-help groups not only provide collective security but also serve as platforms for training, innovation, and advocacy. This mirrors findings from Ghana’s Savannah zone and Ethiopia’s Tigray region, where community-based adaptation planning has led to improved resource governance and food security outcomes [92,93]. Policymakers should recognize and resource these grassroots institutions, embedding them in national climate adaptation frameworks and decentralization agendas.

The integration of indigenous knowledge systems is equally vital. Across the Horn of Africa, traditional weather forecasting, seed selection, and livestock management practices offer context-appropriate, culturally embedded solutions. Studies in Sudan and Namibia highlight how blending local knowledge with scientific tools enhances uptake and effectiveness of adaptation strategies [41]. In West Pokot, similar synergies can be fostered by integrating elders and indigenous leaders into climate planning committees, extension outreach, and research validation processes.

Finally, infrastructure investment, in roads, markets, water systems, and veterinary services, is foundational for resilience and productivity. The infrastructural deficits in ASAL counties like West Pokot mirror those in northern Nigeria and central Chad, where lack of access to inputs and markets undermines even well-designed policies [4]. Governments and donors must therefore direct adaptation finance not only to programmatic interventions but also to physical infrastructure that supports durable development.

5. Conclusions and Perspectives

This study has examined how demographic characteristics, institutional structures, and livelihood strategies collectively shape household resilience to climate variability and drought in West Pokot County, one of Kenya's most climate-vulnerable arid and semi-arid land (ASAL) regions. Utilizing a mixed-methods approach that integrated household survey data with Multinomial Logistic Regression (MLR), Multiple Correspondence Analysis (MCA), and Stepwise Linear Regression (SLR), the findings reveal that resilience is a dynamic and context-specific outcome, driven by the interplay of socioeconomic traits, institutional access, and adaptive behaviors. Gender and education emerged as significant determinants of asset ownership and livelihood choices, with male-headed and older households maintaining larger livestock herds, while more educated individuals tended to diversify their income sources beyond agriculture. Access to veterinary services, drought-tolerant inputs, and participation in community networks were found to be critical enablers of both livestock and crop productivity. However, the analysis also identified trade-offs: strategies that improve livestock resilience may inadvertently constrain crop yields due to labor and resource competition. Moving forward, resilience-building efforts must acknowledge and address these sectoral trade-offs through integrated approaches. This includes the provision of gender-responsive and youth-inclusive extension services, the integration of indigenous knowledge with scientific innovation, investments in rural infrastructure and irrigation, and the promotion of participatory governance mechanisms. These insights not only inform targeted adaptation strategies in West Pokot but also offer broader lessons for building sustainable resilience in drought-prone ASAL regions across sub-Saharan Africa.

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