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Household-Level Anthropogenic Activities Contributing to Weather Variability: A Case Study of Migori County

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Abstract

This study examined household-level anthropogenic activities contributing to weather variability in Migori County, Kenya. The study was guided by Sustainable Livelihoods Framework and Driver-Pressure-State-Impact-Response (DPSIR) Framework. A descriptive research design was adopted, targeting approximately 10,000 households across Awendo, Uriri, and Nyatike sub-counties. A sample of 384 households was selected using Yamane's formula, with 310 valid responses obtained (80.7% response rate). Stratified and systematic sampling techniques were used for household selection, while purposive sampling identified key informants. Primary data were collected using structured questionnaires, while secondary data on rainfall and temperature trends (2011–2023) were obtained from the Kenya Meteorological Department. Data were analyzed using SPSS version 26, applying descriptive statistics, Pearson correlation, ANOVA, and multiple regression analysis. Findings indicated that household activities such as biomass fuel use (90% reliance on firewood), land clearing through burning (50%), overgrazing (60% reported continuous grazing), and intensive cultivation (47.7% of households fully utilizing land for crops) were widely practiced in the study area. Correlation analysis showed strong positive relationships between anthropogenic activities and weather variability, with land clearing (r = .742) and biomass fuel use (r = .706) showing the strongest associations. Regression results revealed that household activities significantly predicted weather variability ($R^2 = 0.663$, $p < 0.001$), with land clearing (β = .389), biomass fuel use (β = .341), overgrazing (β = .297), and intensive

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cultivation (β = .241) all contributing significantly. Historical climate analysis further confirmed significant rainfall (p = 0.0002) and temperature (p = 0.031) variability over the study period. The study concludes that household-level anthropogenic activities significantly contribute to weather variability in Migori County through vegetation loss, greenhouse gas emissions, soil degradation, and disruption of local hydrological processes. The findings highlight the need for sustainable household energy use, improved land management practices, and strengthened environmental awareness programs to reduce climate-related risks at the local level.

Keywords: Weather variability, Anthropogenic Activities, Biomass Fuel, Land Use, Migori County, Kenya

Introduction

Climate change and weather variability have emerged as the most critical challenges of the twenty-first century, with anthropogenic activities recognized as the primary catalysts for the alteration of atmospheric and terrestrial systems (du Plessis, 2018; Singh et al., 2025). Globally, human influence has warmed the climate at an unprecedented rate, as emissions from energy use, land-use change, and industrial processes disrupt the Earth's energy balance (Swagatika Priyadarshini et al., 2025). The historical influence of anthropogenic climate change on agricultural productivity has been quantified through robust econometric modeling, revealing that anthropogenic climate change has reduced global agricultural total factor productivity by approximately 21% since 1961, a slowdown equivalent to losing the last seven years of productivity growth, with effects substantially more severe in warmer regions such as Africa and Latin America where reductions reach 26–34% (Ortiz-Bobea et al., 2021). At the domestic level, approximately three billion people continue to depend on polluting fuels like wood, charcoal, and biomass for cooking and heating, which increases carbon emissions and alters regional climate dynamics (Stoner et al., 2020). These practices generate 1–2.4 gigatons of emissions annually, representing 2–7% of global anthropogenic emissions, while inefficient combustion releases significant quantities of carbon dioxide, methane, and black carbon (Bailis et al., 2015).

In sub-Saharan Africa, livelihoods are inextricably linked to climate-sensitive natural resources, making smallholder agricultural systems exceptionally vulnerable to these perturbations (Schlenker & Lobell, 2010). Systematic reviews highlight that while farmers are responding to changes in rainfall and temperature, adoption of mitigation strategies is hindered by limited access to extension services, credit, and climate information (Mosha & Ngulube, 2025). In the Sahel region of Mali, changing rainfall patterns and agro-climatic risks have been strongly linked to land degradation and unsustainable farming systems practiced at the household level, including overcultivation, deforestation, and charcoal production that contributed

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to rising temperatures and rainfall variability, negatively affecting mixed farming systems and household livelihoods (Amadou & Diakarya, 2021). Furthermore, population growth and poverty have intensified environmental degradation, with eastern Africa projected to lose significant forest land reaching approximately 14 × 10^4 square kilometers by 2040 relative to the 1995–2014 baseline due to the transition from forest to cropland (Rosenthal, Balakrishnan, & Bruce, 2017).

In Kenya, weather variability is evidenced by irregular rainfall, prolonged droughts, and flash floods (Kerich et al., 2025). Scientific evidence indicates that rainfall variability has intensified across Kenyan counties between 1981 and 2021 due to both natural climatic processes and anthropogenic influences, with substantial variability of local rainfall patterns documented at national and county levels, including anomalous patterns of both wetting and drying in the long and short rainy seasons and increased frequency of extreme wet and dry events, particularly after 2013 when coherence between ENSO and rainfall diminished (Kotikot et al., 2024). The Kenya Meteorological Department (2023) confirmed that 2023 continued a long-term warming trend, with severe flooding in river basins like the Tana and Lake Victoria leading to loss of life and property. The macroeconomic impact is severe; Kenya's Nationally Determined Contributions estimate annual socioeconomic losses of 3–5% of GDP between 2010 and 2020 due to climate events, while floods and droughts create annual fiscal liabilities of 2–2.8% of GDP (Center for Strategic and International Studies, 2025). Anthropogenic activities, including charcoal burning, poor farming methods, and deforestation, significantly contribute to these extremes (Kariuki et al., 2024). Notably, the land use and forestry sector accounted for 41% of total emissions in 2024, with Kenya losing 386,000 hectares of tree cover between 2001 and 2023, primarily due to shifting cultivation and commercial activities (Center for Strategic and International Studies, 2025; Farmonaut, 2025).

The Lake Region Economic Bloc, including Migori County, represents a densely populated area where household activities intersect with acute climate vulnerability (Royal Danish Embassy, 2025). Farmers in this region are particularly susceptible to declining yields and population pressure, as business-as-usual production leads to further land-use change and emissions (Kogo et al., 2021). Empirical assessments of livelihood vulnerability in Kenya's arid and semi-arid lands demonstrate that smallholder farmers face high exposure to extreme weather events, with studies documenting that over 76% of farmers experience extreme weather conditions, and vulnerability indices indicating that sensitivity and exposure consistently outweigh adaptive capacity (Muia et al., 2024).

Migori County serves as a distinctive case study for examining these anthropogenic contributions. Its rain-fed economy faces increasing exposure to erratic climate patterns that disrupt productivity and water availability (County Government of Migori, 2024). Studies conducted in the Migori River Watershed

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established that rural households are increasingly vulnerable to climate variability due to environmental and socio-economic stressors linked to unsustainable resource use practices, with Livelihood Vulnerability Index scores indicating moderate vulnerability across all watershed zones but notable variations between them, as downstream households exhibit the highest vulnerability attributed to lower adaptive capacity, increased exposure, and heightened sensitivity, while upstream households demonstrate the least vulnerability due to lower sensitivity and exposure as well as better adaptive capacity (Opiyo et al., 2023). Satellite analyses confirm that built-up areas and cropland expanded between 1980 and 2020 as forested zones and wetlands contracted (Migori County Government, 2023).

At the household level, daily survival strategies particularly energy use drive environmental change. Traditional earth kilns in Kenya convert only 10–15% of biomass into charcoal, venting the remainder as pollutants (Huduma Global, 2026). Additionally, urbanization compounds these issues; empirical research in Addis Ababa, Ethiopia, demonstrates that urban land-use and land-cover changes significantly affect microclimate dynamics, with built-up areas and green spaces contributing 92.1% of land surface temperature variations, where a 5% increase in built-up area implies a 1.6°C temperature rise (Negesse et al., 2024).

Despite the recognition of these local forces, systematic research quantifying specific household behaviors that drive weather variability remains scarce in Migori County. Most assessments focus on broad regional trends without disaggregating the impact of individual actions such as waste disposal or specific farming practices (County Government of Migori, 2024). This knowledge gap limits the efficacy of climate adaptation planning, as interventions may address symptoms rather than the behavioral drivers of climatic instability. This study, therefore, seeks to assess the household-level anthropogenic activities influencing weather variability in Migori County, providing an empirical basis for community-centered strategies that align with national climate priorities and address the specific behavioral drivers of local environmental change.

Theoretical Framework

Sustainable Livelihoods Framework

The Sustainable Livelihoods Framework, originally conceptualized by Chambers and Conway (1992) and subsequently operationalized by the United Kingdom's Department for International Development (DFID, 1999), offers a people-centered approach for understanding how households assemble and deploy assets to construct livelihood strategies under conditions of vulnerability. The framework posits that households possess five core capital assets such as human, natural, physical, financial, and social capital which they combine within a vulnerability context shaped by shocks, trends, and seasonality to pursue diverse livelihood

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strategies (DFID, 1999). These strategies yield livelihood outcomes that can either enhance or degrade the natural resource base.

For this study, the SLF is particularly valuable because it moves beyond simplistic behavioral explanations to situate household anthropogenic activities such as charcoal production, fuelwood extraction, unsustainable cultivation, and wetland encroachment within the structural context of asset poverty and livelihood insecurity. In Migori County, where households depend heavily on rain-fed agriculture and natural resource extraction, the framework illuminates why households engage in environmentally depleting practices not out of ignorance, but as rational adaptations to limited asset portfolios and high vulnerability contexts.

Driver-Pressure-State-Impact-Response (DPSIR) Framework

The DPSIR framework, developed by the Organisation for Economic Co-operation and Development (OECD, 1993) and subsequently elaborated by the European Environment Agency through its environmental indicators typology (Smeets & Weterings, 1999), provides an integrated environmental assessment tool that traces causal chains from anthropogenic drivers to ecological responses. The framework categorizes environmental interactions into five linked components: driving forces (underlying socio-economic trends), pressures (direct human activities), state (environmental conditions), impacts (consequences for ecosystems and human welfare), and responses (policy and institutional interventions).

For this study, the DPSIR framework is ideally suited to structure the analysis of how household-level activities function as direct pressures that alter the state of local atmospheric and terrestrial systems, thereby generating weather variability impacts that feedback to affect household livelihoods. Household charcoal burning, biomass combustion, deforestation for agricultural expansion, and poor waste disposal constitute explicit pressures that modify land cover, albedo, and local hydrological cycles, which in turn shift microclimatic states including temperature regimes and rainfall patterns. The framework's response component also ensures that the study does not remain diagnostic but informs policy interventions tailored to the specific pressure points identified. In Migori County, the DPSIR framework enables a systematic disaggregation of household behaviors as discrete pressure variables, allowing the study to isolate which specific anthropogenic activities most significantly influence local weather variability and to recommend precise, evidence-based policy responses.

Methodology

The study was conducted in Migori County (Figure 1), located in the south-western part of Kenya. The county borders Homa Bay County to the north, Kisii County and Narok County to the east, the Tanzania border to the south, and Lake

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Victoria to the west. Migori County lies between latitudes 1°24' and 1°40' South and longitude 34°50' East and covers approximately 2,596.5 km², including water surface areas. According to the 2019 Kenya Population and Housing Census, the county had a population of about 1,116,436 people. The county experiences an inland equatorial climate influenced by altitude, relief, and proximity to Lake Victoria. Annual rainfall ranges between 700 mm and 1800 mm, with long rains occurring from March to May and short rains from September to November. Dry periods commonly occur between December and February and again between June and September. Average annual temperatures range between 24°C and 31°C (County Government of Migori, 2024).

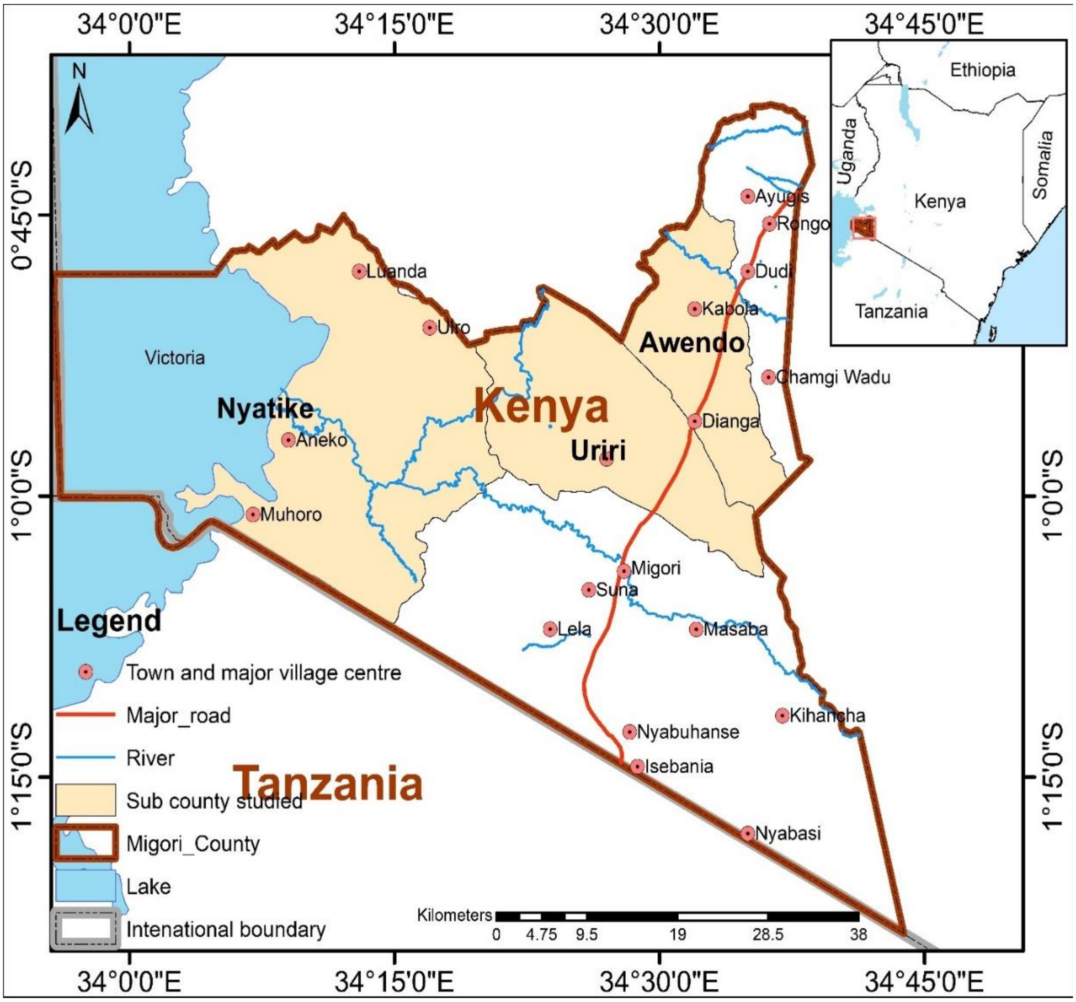

Figure 1: Study area map

The study employed a descriptive research design to examine household-level anthropogenic activities contributing to weather variability in Migori County. The design enabled systematic collection of quantitative and qualitative information

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regarding household environmental practices, perceived weather changes, and historical climate trends without manipulating study variables. The target population comprised approximately 10,000 households from Awendo, Uriri, and Nyatike sub-counties.

The sample size for household respondents was determined using Yamane's (1967) formula at a 5% margin of error, generating a sample size of 384 respondents. A multi-stage sampling approach incorporating stratified, systematic, and purposive sampling techniques was used. The county was first stratified according to sub-counties to capture variations in environmental activities and climatic conditions. Systematic sampling was then applied in selecting households, where every fifth household from the sampling frame was selected until the desired sample size was attained. Purposive sampling was used to select agricultural extension officers and meteorological officers who provided expert information regarding climate variability and environmental degradation.

Primary data were collected using structured questionnaires administered to household respondents. Secondary data were obtained from meteorological records, government publications, environmental reports, and scholarly literature. Historical rainfall and temperature records covering the period between 2011 and 2023 were obtained from the Kenya Meteorological Department to establish long-term weather variability trends within Migori County.

A pilot study was conducted in Nyatike Sub-County using approximately 10% of the sample size to assess the clarity, relevance, and consistency of the research instruments. Feedback from the pilot study guided revision of ambiguous items and improvement of questionnaire structure before the actual field survey. Validity of the instruments was assessed through face and content validity with guidance from supervisors to confirm adequacy of the questionnaire items in measuring household anthropogenic activities and weather variability indicators. Reliability of the instruments was tested using Cronbach's Alpha coefficient, which yielded a reliability value of 0.89, indicating high internal consistency of the research instrument.

Before commencement of data collection, the researcher obtained an introductory letter from the university and secured a research permit from the National Commission for Science, Technology and Innovation. Permission was further sought from county administrative officials and local leaders to facilitate access to respondents. Respondents were informed about the objectives of the study, confidentiality of responses, and voluntary participation before administration of the questionnaires.

Collected data were coded and analyzed using Statistical Package for Social Sciences (SPSS) version 26. Descriptive statistics including frequencies, percentages, means, and standard deviations were used to summarize household anthropogenic activities and weather variability indicators. Historical rainfall and temperature

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trends were analyzed using descriptive trend analysis. Pearson correlation analysis was conducted to establish relationships between household anthropogenic activities and weather variability. Multiple regression analysis was further used to determine the extent to which biomass fuel use, land clearing activities, overgrazing, and intensive cultivation predicted weather variability in Migori County. Statistical significance was tested at the 0.05 level.

The multiple regression model used in the study was expressed as:

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\varepsilon$$

Where:

Y = Weather variability
β_0 = Constant term (intercept)
$\beta_1-\beta_4$ = Regression coefficients
X_1 = Biomass fuel use
X_2 = Land clearing activities
X_3 = Overgrazing practices
X_4 = Intensive cultivation
ε = Error term

Results and Discussion

Response Rate and Demographic Characteristics of Respondents

The study achieved a high response rate, indicating that the collected data was adequate and representative for analysis. Out of the 384 questionnaires distributed to households in Migori County, 310 were fully completed and returned, translating to a response rate of 80.7%, while 74 questionnaires were not returned. According to Creswell and Creswell (2017), a response rate above 70% is considered excellent for analysis and generalization of findings. The high response rate in this study was attributed to effective training of research assistants and administration of well-structured questionnaires.

The study further assessed demographic characteristics of the respondents, including gender, age, and education level, because these factors influence household environmental practices, resource utilization, and perceptions regarding weather variability. The findings in Table 1 indicate that male respondents constituted the majority at 60%, while female respondents accounted for 40%. This implies that most household and environmental management decisions within the study area were mainly influenced by male household heads. However, the proportion of female-headed households also demonstrates the significant role women play in household environmental management and agricultural activities. These findings agree with Doss (2014), who reported that male-headed households dominate agricultural decision-making in many African rural communities, although

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women increasingly participate in household resource management and food security activities.

Table 1: Response Rate and Demographic Characteristics of Respondents

Variable	Category	Frequency (f)	Percentage (%)
Response Rate	Returned questionnaires	310	80.7
	Unreturned questionnaires	74	19.3
	Total questionnaires distributed	384	100
Gender	Male	186	60.0
	Female	124	40.0
	Total	310	100
Age of Respondents (Years)	18–30	31	10.0
	31–40	82	26.5
	41–50	114	36.7
	51–60	55	17.6
	61–70	20	6.5
	Over 70	8	2.7
	Total	310	100
Education Level	Primary	78	25.2
	Secondary	158	51.0
	Tertiary	74	23.9
	Total	310	100

The age distribution results revealed that most respondents (36.7%) were aged between 41 and 50 years, followed by 26.5% aged between 31 and 40 years. Respondents aged between 51 and 60 years accounted for 17.6%, while those aged 18–30 years represented 10%. Respondents aged between 61 and 70 years constituted 6.5%, whereas only 2.7% were aged above 70 years. These findings suggest that most respondents were within economically active age brackets and therefore possessed adequate experience regarding household activities and weather-related changes within Migori County. Similar observations were reported by Tiwari et al. (2019), who noted that middle-aged household heads are more actively involved in environmental and farming decisions because of their experience, physical capability, and economic responsibilities.

Regarding education level, the findings showed that 51% of the respondents had attained secondary education, 25.2% had primary education, while 23.9% had

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tertiary education. The relatively high proportion of respondents with secondary and tertiary education suggests that most participants possessed adequate literacy levels to understand environmental conservation issues and weather variability patterns. Educated respondents are more likely to access environmental information and adopt sustainable environmental management practices. Similar findings were reported by Ahmed and Melesse (2018), who established that education improves awareness of climate variability and adoption of sustainable environmental management practices.

Human Factors Influencing Weather Variability

The objective of this study was to identify human factors contributing to weather variability in selected areas of Migori County. Human activities greatly affect the environment, hence having local and regional effects on weather. These reasons have brought about changes in the pattern of rainfall, temperature fluctuation and the overall climatic change experienced globally and within this region. Understanding the human factors that contribute to the variability in weather in Migori County will be important in devising ways of mitigating their impact effectively.

Burning of Biomass and Fossil Fuels

The study assessed the types of fuel used for domestic purposes by households. The results are summarized in Figure 2 below.

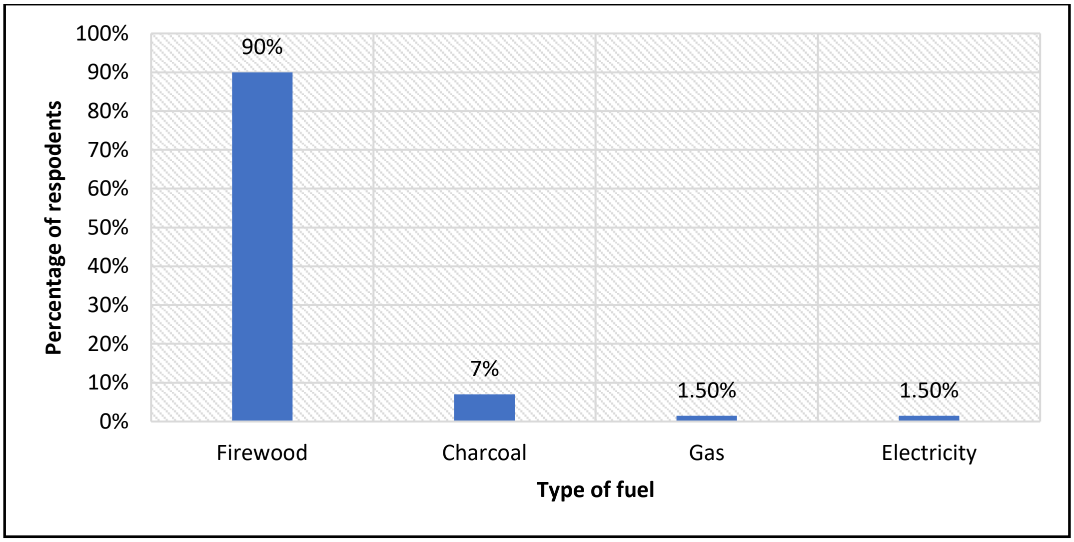

Figure 2: Type of fuel used by the Households in the study area

The findings clearly show that firewood biomass served as the primary fuel source for 90% of households, while 7% relied on charcoal, and 1.5% each used gas

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and electricity. This heavy dependence on biomass fuels is consistent with national trends in Kenya. According to the Kenya Integrated Household Budget Survey, 68.3% of households nationwide depend on firewood as their main cooking fuel, with this figure rising to approximately 90% in rural areas (Nyambane et al., 2014). The firewood is often sourced from farmlands, public and private plantations and indigenous forests as either live or deadwood (Chisika, Park & Yeom, 2021). The reliance on firewood and charcoal is particularly pronounced in rural regions, where access to alternative energy sources is limited. Jung and Huxham, (2018) note that in rural Kenya, firewood is the main cooking fuel for 68% of the population. This preference is influenced by factors such as availability, cost, and cultural practices.

The minimal use of gas and electricity, each at 1.5%, reflects challenges in accessing and affording these cleaner energy sources. Mbaka et al. (2019) highlight that despite efforts to promote clean energy, consumption remains low, especially in rural areas where infrastructure and affordability are significant barriers. The use of biomass for cooking and heating, along with the burning of fossil fuels for transportation and energy production, releases significant amounts of greenhouse gases into the atmosphere. These emissions contribute to the greenhouse effect, leading to an increase in global temperatures. The resultant climate change has a direct impact on local weather variability, causing shifts in temperature patterns, altered rainfall seasons, and the increased frequency of extreme weather events.

Land Preparation Activities

Land preparation practices influence local environmental conditions, potentially affecting weather variability. The Figure 3 below illustrates the types of land preparation methods commonly used by households in the area, reflecting choices based on resource availability, labor, and farming practices.

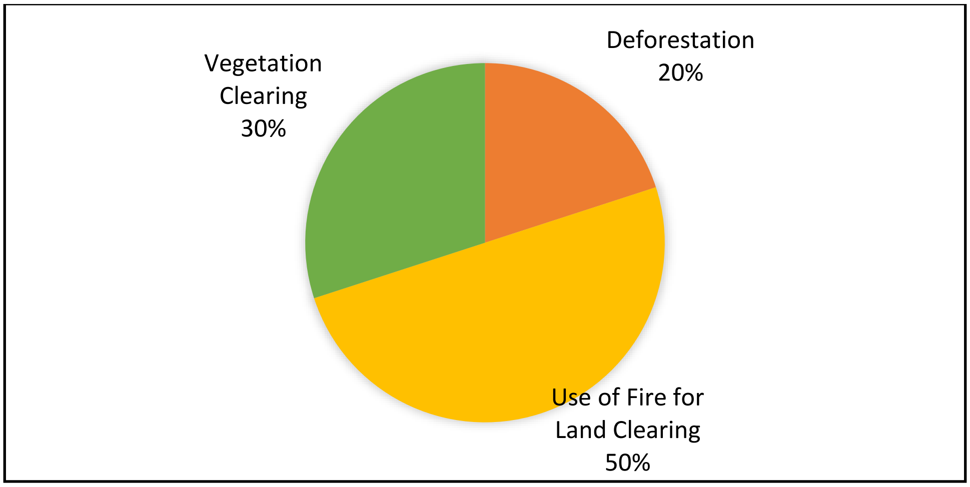

Figure 3: Land preparation activities carried out by the households in the study area

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The findings revealed that the majority of respondents (50%) used fire for land clearing, 30% practiced vegetation clearing, and 20% cut down trees to create space for farming. These practices are prevalent in various regions of Kenya and have significant environmental implications. The use of fire, or slash-and-burn agriculture, is a common method for clearing land due to its cost-effectiveness and efficiency. However, this practice contributes to deforestation, loss of biodiversity, and increased greenhouse gas emissions. According to the Kenya Forest Service, such methods have led to substantial forest cover loss, exacerbating climate change effects (Kitheka, 2019). Manual vegetation clearing involves removing shrubs and undergrowth to prepare land for cultivation. While less destructive than burning, it can still lead to soil erosion and habitat loss if not managed sustainably. Felling trees to expand agricultural land reduces forest cover, impacting local ecosystems and weather patterns. The World Bank reports that land degradation, including deforestation, affects approximately 30% of Kenya's land area, leading to decreased agricultural productivity and increased vulnerability to climate change (Nkonya et al., 2018).

Overgrazing

The study examined the extent of overgrazing in the study area, focusing on livestock density, vegetation cover and soil quality. Overgrazing occurs when livestock graze excessively on a particular piece of land, removing vegetation faster than it can naturally regenerate. Figure 4 illustrate the types of livestock kept by households.

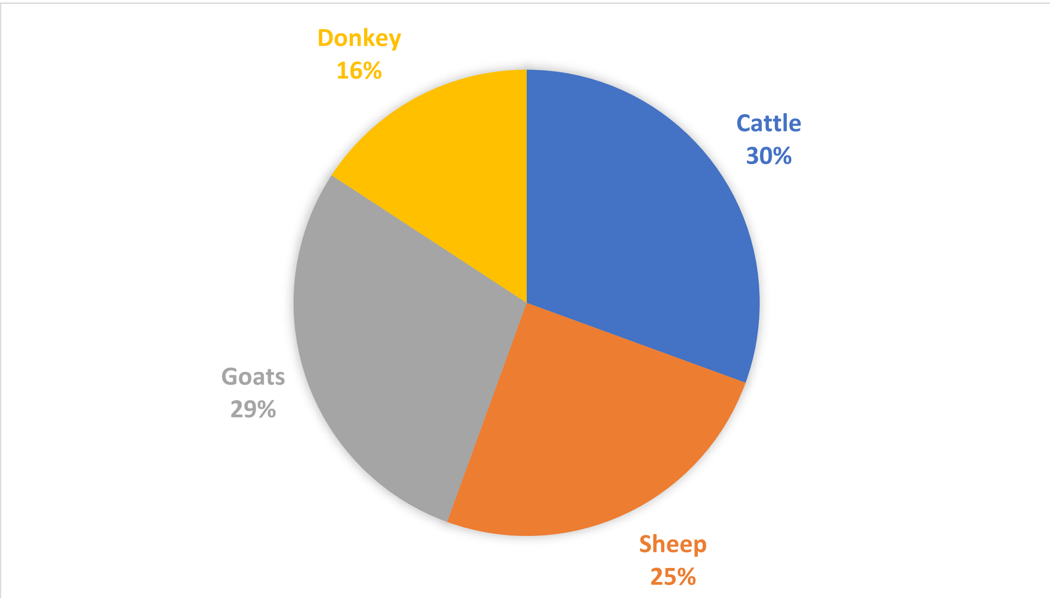

Figure 4: Number of Livestock kept by the households

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The results revealed that 70% of households reported keeping cattle, goats, and sheep, with an average of 10 livestock per household. Among these, 60% of respondents admitted to grazing their animals on communal lands without rotational practices, leading to continuous grazing on the same land areas. Vegetation cover analysis indicated a 40% reduction in grass and shrub cover over the past five years, with visible signs of soil erosion in 65% of the grazing areas. These findings suggest that overgrazing has led to diminished vegetation cover, which can contribute to local weather variability.

Overgrazing contributes to weather variability by stripping vegetation from the land, leading to soil degradation and erosion. Without sufficient plant cover, soil loses its ability to retain moisture, reducing local humidity and affecting the water cycle, as less water is available for evapotranspiration. This disruption impacts rainfall patterns, often resulting in decreased precipitation and increased temperatures. Additionally, overgrazing limits carbon sequestration, as fewer plants are available to capture carbon dioxide, thereby contributing to greenhouse gas accumulation and climate warming. The cumulative effect of these changes creates localized shifts in weather patterns, exacerbating weather variability in affected areas.

Over cropping

Overcropping can lead to weather variability by depleting soil nutrients and reducing soil fertility, which in turn affects vegetation cover and soil structure. Respondents were asked to indicate the proportion of land crops and Table 2 present their summarized response. The proportion of land under crops as compared to livestock, helps to assess the amount of cropping in terms of under cropping or over cropping.

Table 2: The proportion of land under crops by the Households in the study area

Proportion of land under crops on the total land owned (acre)	Frequency	Percentage
1/4	22	7.1
1/2	98	31.6
1	148	47.7
2 and above	42	13.6
Total	**310**	**100**

The findings in Table 2 reveal the distribution of land under crops among households in the study area, illustrating that nearly half (47.7%) of households allocate their entire landholding to crops. Additionally, 31.6% of households use half of their land for cropping, while smaller proportions, 13.6% and 7.1%, dedicate two

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acres or more and a quarter of their land, respectively, to cultivation. This high intensity of land use, particularly where full land areas are under continuous cropping, has implications for soil health, vegetation cover, and, subsequently, weather variability. The heavy reliance on crop farming without sufficient fallow periods can lead to soil degradation, as reported by Waswa (2012), who observed that continuous cropping exhausts soil nutrients, reduces organic matter, and increases susceptibility to erosion. Over time, degraded soils retain less moisture and reduce vegetation cover, impacting the water cycle and contributing to local climate variability (Wamalwa, 2020). Furthermore, the depletion of organic matter in soils limits carbon sequestration, exacerbating greenhouse gas emissions and thereby influencing climate variability (Elbasiouny et al., 2022). As shown above, the significant proportion of land continuously under crops suggests a potential cycle of land degradation, reducing the land's resilience to climate stressors and intensifying weather variability in the region.

Weather Variability Trends in Migori County

Historical weather records obtained from the Kenya Meteorological Department revealed considerable rainfall and temperature fluctuations in Migori County between 2011 and 2023, indicating increasing weather variability within the region. Rainfall records obtained from the Kenya Meteorological Department indicate irregular distribution of precipitation across seasons, with annual totals ranging from 575 mm in 2017 to 875 mm in 2021. The short rains showed greater instability compared to long rains, confirming growing unpredictability in seasonal rainfall onset, duration, and intensity. Temperature records similarly indicate upward and fluctuating trends, with higher values recorded in recent years (2021–2023). The combined variability in rainfall and temperature suggests weakening climatic stability, consistent with evidence that human-driven atmospheric changes are altering hydrological cycles and regional climate systems (du Plessis, 2018; Singh et al., 2025).

These patterns align with global evidence showing that anthropogenic activities have intensified climate instability through disruption of the Earth's energy balance. Studies indicate that emissions from energy use, land-use change, and inefficient combustion processes significantly alter atmospheric composition and contribute to rising temperatures and irregular precipitation patterns (Swagatika Priyadarshini et al., 2025). At a global scale, anthropogenic climate change has already reduced agricultural productivity by about 21% since 1961, with Africa experiencing some of the highest losses due to higher baseline temperatures and sensitivity of rain-fed systems (Ortiz-Bobea et al., 2021). These findings help explain the observed rainfall and temperature fluctuations in Migori County, where livelihoods depend heavily on climate-sensitive agriculture.

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Statistical Analysis of Human Factors Influencing Weather Variability

To establish the relationship between household anthropogenic activities and weather variability in Migori County, Pearson correlation and multiple regression analyses were conducted. The analysis focused on key household activities identified in the study, including biomass fuel use, land clearing practices, overgrazing, and intensive cultivation. Weather variability indicators included irregular rainfall patterns, prolonged dry periods, rising temperatures, and perceived seasonal unpredictability.

Table 3: Pearson Correlation Analysis Between Household Anthropogenic Activities and Weather Variability

Variable	1	2	3	4	5
1. Biomass fuel use	1				
2. Land clearing activities	.612**	1			
3. Overgrazing practices	.544**	.683**	1		
4. Intensive cultivation	.471**	.598**	.621**	1	
5. Weather variability	.706**	.742**	.689**	.655**	1

Note: $p < .01$

The results in Table 3 indicate significant positive relationships between household anthropogenic activities and weather variability in Migori County. Land clearing activities showed the strongest correlation with weather variability ($r = .742$, $p < .01$), followed by biomass fuel use ($r = .706$, $p < .01$), overgrazing practices ($r = .689$, $p < .01$), and intensive cultivation ($r = .655$, $p < .01$). These findings imply that increased engagement in environmentally degrading household activities was associated with increased weather variability within the study area. The findings support observations that deforestation, biomass burning, vegetation destruction, and land degradation alter local hydrological processes and atmospheric conditions, contributing to irregular rainfall patterns and rising temperatures. This pattern aligns with evidence from sub-Saharan Africa showing that deforestation, overcultivation, and charcoal production at household level significantly contribute to land degradation and altered rainfall regimes (Amadou & Diakarya, 2021).

A multiple regression analysis was further conducted to determine the combined influence of household anthropogenic activities on weather variability.

Table 4: Model Summary for Regression Analysis

Model	R	R^2	Adjusted R^2	Std. Error of Estimate
1	.814	.663	.658	.421

The regression model produced a correlation coefficient (R) of .814, indicating a strong relationship between household anthropogenic activities and weather variability. The coefficient of determination ($R^2 = .663$) implies that

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approximately 66.3% of the variation in weather variability within Migori County could be explained by biomass fuel use, land clearing, overgrazing, and intensive cultivation. This suggests that household environmental practices substantially contribute to localized climatic changes within the study area.

Table 5: ANOVA Results for Regression Model

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	108.472	4	27.118	152.943	.000
Residual	54.081	305	0.177		
Total	162.553	309			

The ANOVA results in Table 5 indicate that the regression model was statistically significant ($F = 152.943$, $p < .001$). This demonstrates that the selected household anthropogenic activities significantly predicted weather variability in Migori County. These findings align with evidence from Kenya showing that anthropogenic land-use changes, particularly in agriculture and forestry sectors, account for a large proportion of emissions and environmental degradation (Kariuki et al., 2024).

Table 6: Regression Coefficients for Household Anthropogenic Activities and Weather Variability

Variable	Unstandardized B	Std. Error	Beta	t	Sig.
Constant	0.842	0.214		3.935	.000
Biomass fuel use	0.318	0.057	.341	5.579	.000
Land clearing activities	0.371	0.061	.389	6.082	.000
Overgrazing practices	0.284	0.053	.297	5.358	.000
Intensive cultivation	0.226	0.049	.241	4.612	.000

The regression coefficients in Table 6 reveal that all household anthropogenic activities had a positive and statistically significant effect on weather variability. Land clearing activities had the strongest influence ($\beta = .389$, $p < .001$), followed by biomass fuel use ($\beta = .341$, $p < .001$), overgrazing practices ($\beta = .297$, $p < .001$), and intensive cultivation ($\beta = .241$, $p < .001$). The findings suggest that increased household environmental degradation activities significantly contributed to changing weather conditions within Migori County.

The regression equation derived from the model was:

$$Y = 0.842 + 0.318X_1 + 0.371X_2 + 0.284X_3 + 0.226X_4$$

The findings therefore demonstrate that household-level anthropogenic activities significantly contributed to weather variability in Migori County through vegetation loss, greenhouse gas emissions, declining soil quality, and disruption of local ecological systems. This finding is consistent with studies showing that traditional energy use and land degradation significantly contribute to carbon emissions and local climate modification (Bailis et al., 2015; Stoner et al., 2020). At

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the local level, studies in the Lake Region Economic Bloc show that household environmental practices directly influence vulnerability to climate variability, with high exposure to extreme weather conditions reducing adaptive capacity among smallholder farmers (Muia et al., 2024). In Migori County specifically, expansion of cropland, reduction of forest cover, and increased household energy demand have intensified environmental pressure (Migori County Government, 2023). These dynamics reinforce the findings of this study, where household activities significantly predict weather variability.

Conclusion

The study established that household-level anthropogenic activities significantly contribute to weather variability in Migori County. High dependence on biomass fuels, widespread land clearing through burning and tree cutting, continuous grazing, and intensive cultivation have collectively altered vegetation cover, reduced soil quality, and increased greenhouse gas emissions. These processes have contributed to irregular rainfall patterns, rising temperatures, and increasing seasonal unpredictability. Statistical analysis confirmed strong and significant relationships between the identified household activities and weather variability, with land clearing and biomass fuel use emerging as the strongest drivers. Historical climate data further confirmed significant variability in rainfall and temperature over the 2011–2023 period. Overall, household environmental practices play a central role in shaping local climatic conditions in the study area.

Recommendations

1. Households should adopt cleaner and more efficient energy sources such as LPG and electricity to reduce reliance on firewood and charcoal. County government and energy agencies should expand access to affordable clean energy infrastructure, particularly in rural areas where biomass dependency remains high.
2. There is need to strengthen community-based environmental conservation programs focusing on tree planting, agroforestry, and restoration of degraded landscapes to improve vegetation cover and enhance local climate regulation.
3. County agricultural and environmental offices should promote sustainable land management practices such as controlled grazing, rotational grazing systems, and conservation agriculture to reduce land degradation and improve soil resilience.
4. Public awareness programs should be intensified to educate households on the link between daily environmental practices and weather variability, with emphasis on long-term climate risks associated with unsustainable land use.

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5. Policy enforcement on deforestation, charcoal production, and wetland encroachment should be strengthened to reduce continued environmental degradation at household and community levels.

Future Research

Future studies should examine the impact of household-level anthropogenic activities on extreme weather events such as floods and droughts using longer climate datasets and higher spatial resolution data. Further research should also incorporate remote sensing and GIS techniques to quantify land-use changes and vegetation loss over time in relation to weather variability. In addition, comparative studies across different counties in Kenya would help establish regional differences in household contributions to climate variability and improve the generalizability of findings.

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