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Exploring the nexus between climate variability, domestic water resources, and household livelihoods in Kisii and Nyamira Counties, Kenya

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Abstract
Climate variability has emerged as a critical driver of water insecurity and livelihood vulnerability across Sub-Saharan Africa. While much research has focused on arid and semi-arid lands, high rainfall regions such as Kisii and Nyamira Counties in Kenya continue to experience significant climate-induced water stress, with profound implications for household welfare. This study examined the nexus between climate variability, domestic water resources, and household livelihoods in Kisii and Nyamira Counties. A mixed-methods approach was employed, combining household surveys, key informant interviews, and focus group discussions. Quantitative data were analyzed using descriptive statistics, Chi-square tests, correlation analyses, and Principal Component Analysis (PCA) to derive composite indices of climate and water stress. Regression models were applied to assess the influence of climate variability on the combined livelihood index, while qualitative data provided contextual insights.

The findings reveal that households face recurring water-related challenges associated with erratic rainfall, droughts, floods, and seasonal variability. Domestic water access was found to be unreliable, with households reporting increased distances to water sources, reduced reliability of springs and streams, and higher costs of accessing safe water. These disruptions had a significant impact on livelihoods, particularly affecting agricultural productivity, household health, and income-generating activities. Regression analysis confirmed strong associations between climate-induced water stress indices and livelihood outcomes, underscoring water's pivotal role in shaping household resilience.

The study concludes that despite relatively high rainfall, Kisii and Nyamira households remain highly vulnerable to climate-induced water stress. It recommends strengthening localized water governance, investing in climate-resilient water infrastructure, and integrating indigenous adaptation practices into policy frameworks to enhance household livelihood security.

Keywords: Kisii, Nyamira, Kenya, climate variability, domestic water resources, livelihoods, water stress

1. Introduction
Climate variability has emerged as one of the most critical challenges affecting water security and rural livelihoods globally. Changes in rainfall distribution, increasing frequency of droughts, floods, and extreme temperature events are reshaping hydrological systems and undermining the availability of water for domestic and productive uses (IPCC, 2022) [4]. In Sub-Saharan Africa, where a large proportion of the population depends directly on natural resources, climate variability exacerbates water stress, thereby threatening household welfare and economic development (Mugambiwa & Tirivangasi, 2017) [7].

Domestic water resources play a pivotal role in sustaining livelihoods, not only by supporting basic needs such as drinking, cooking, and sanitation, but also by underpinning agricultural production, livestock rearing, and small-scale enterprises. The Sustainable Livelihoods Framework emphasizes water as a critical asset that interacts with other capitals such as human, natural, financial, and social, to determine household resilience (Scoones, 1998) [12]. Consequently, fluctuations in water availability caused by climate variability often translate directly into livelihood insecurity (Olago *et al*., 2017) [10].

In Kenya, climate variability has intensified over the past three decades, manifesting in erratic rainfall, recurrent droughts, and floods, all of which have disrupted domestic water supply systems and increased competition for scarce resources. Kisii and Nyamira Counties, located in the western highlands within the Lake Victoria Basin, are highly dependent on rain fed agriculture and natural water sources. Despite relatively high rainfall compared to arid and semi-arid regions, the two counties face recurring water stress due to uneven distribution of rainfall, seasonal shortages, and growing demand driven by population pressure. This dynamic has profound implications for household livelihoods, given that approximately 90% of the population relies on agriculture and related water-dependent activities (KNBS, 2019).

While previous studies in Kenya have documented the impacts of climate change on agriculture and water resources broadly (Ongoma *et al*., 2018) [11], there is limited empirical evidence on how climate variability specifically influences the nexus between domestic water resources and household livelihoods in highland regions such as Kisii and Nyamira. Understanding this relationship is essential for designing locally relevant adaptation strategies that safeguard household welfare and promote climate-resilient development.

1.1 Objective of the study

This paper seeks to examine the nexus between climate variability, domestic water resources, and household livelihoods in Kisii and Nyamira Counties, Kenya.

2. Literature Review

2.1 Climate Variability and Water Resources

Climate variability, manifested through fluctuating rainfall patterns, droughts, floods, and temperature extremes, has become one of the most pressing global environmental challenges (IPCC, 2022) [4]. Hydrological systems are particularly sensitive to such fluctuations, with impacts evident in groundwater recharge, surface runoff, and water storage (Conway, 2020) [1]. In Sub-Saharan Africa, climate variability has significantly altered the spatial and temporal availability of water resources, exacerbating water insecurity for both domestic and productive uses (Mugambiwa & Tirivangasi, 2017) [7].

Kenya has experienced increasing climate variability over the past three decades, with recurrent droughts, flash floods, and shifts in rainfall onset and cessation. These events have disrupted rural water supply systems and strained natural resources. Even in relatively high rainfall regions, such as the Lake Victoria Basin, climate variability has led to uneven water distribution and seasonal shortages (Olago *et al*., 2017) [10]. Consequently, climate-induced disruptions in water supply present challenges not only for agriculture but also for meeting basic household needs such as drinking, cooking, and sanitation.

2.2 Domestic water resources under climate stress

Domestic water resources are essential for sustaining human health, dignity, and productivity. Access to safe and reliable water influences sanitation, food preparation, hygiene, and overall household welfare (WHO, 2019) [18]. However, climate variability has been shown to directly undermine the stability of domestic water supply systems. Extreme rainfall events often damage water infrastructure, while prolonged dry spells reduce water quality and availability from rivers, springs, and shallow wells (Nyong *et al*., 2007) [9]. In rural African settings, women and children bear the brunt of water scarcity, walking longer distances and spending more time to fetch water, which in turn limits opportunities for education and economic participation (UNDP, 2016) [16].

Studies in Kenya highlight that even regions with relatively abundant rainfall are not immune to water stress. Rapid population growth, land degradation, and deforestation have reduced water availability, while erratic rainfall patterns compound the challenge (Ongoma *et al*., 2018) [11]. For instance, Kisii and Nyamira Counties have experienced increased rainfall intensity but shorter wet seasons, resulting in seasonal water shortages and heightened vulnerability to climate-induced stressors.

2.3 Nexus between water resources and household livelihoods

Water is central to household livelihoods, acting as both a basic necessity and a productive asset. According to the Sustainable Livelihoods Framework (Scoones, 1998) [12], water interacts with other livelihood capitals such as natural, human, financial, physical, and social to shape resilience and well-being. Disruptions in water access undermine health, food security, income generation, and social cohesion, thereby increasing household vulnerability to poverty and climate risks (Ellis, 2000) [2].

Empirical studies demonstrate that water insecurity has direct and indirect effects on livelihoods. In Ethiopia, household food security was found to decline during periods of severe water stress due to reduced crop production and livestock losses (Tessema & Simane, 2019) [13]. In Uganda, unreliable water access increased household expenditure and reduced time available for economic activities (Tumushabe, 2018) [14]. Similarly, in Kenya, rural households facing water scarcity reported compromised hygiene, reduced agricultural productivity, and greater exposure to social conflict over limited resources (Olago *et al*., 2017) [10].

In Kisii and Nyamira, agriculture forms the backbone of livelihoods, with most households dependent on rainfed systems. Climate variability disrupts domestic water availability, which in turn cascades into reduced agricultural productivity, food insecurity, and livelihood stress. Despite these challenges, few studies have systematically examined how the interplay between climate variability and water access shapes household livelihood outcomes in these counties.

2.4 Research Gaps

Although national and county-level policies promote climate adaptation and water resource management, significant gaps remain in integrating localized evidence. Existing research tends to focus on arid and semi-arid lands (ASALs), leaving out highland regions such as Kisii and Nyamira, which face unique water and livelihood challenges caused by climate variability despite higher rainfall. Moreover, the limited incorporation of indigenous knowledge, coupled with weak integration of socio-economic dimensions, hampers the design of effective interventions. This study addresses these gaps by empirically examining the nexus between climate variability, domestic water resources, and household livelihoods in Kisii and Nyamira Counties, Kenya.

3. Methodology

3.1 Study Area

The study was conducted in Kisii and Nyamira Counties, in

the western highlands of Kenya (Figure 3.1). They both fall within the Lake Victoria basin. Kisii County lies between latitudes 0°30′ North and 0°58′ South and longitudes 34°38′ West and 35°00′ East. Nyamira County lies between latitudes 0°30′ North and 0°45′ South and longitudes 34°45′ West and 35°00′ East.

The two counties border each other and have a combined population of 1,872,436, equivalent to 458,719 households (Kenya National Bureau of Statistics, 2019) [6]. Agriculture is central to the socioeconomic development of Kisii and Nyamira Counties, serving as the primary source of livelihood for approximately 90% of the population. Agricultural practices include farming of both food and cash crops, livestock farming, beekeeping, and fish farming. Both Kisii and Nyamira counties feature predominantly hilly terrain, commonly referred to as the "Gusii Highlands," with altitudes ranging between 1,250 and 2,100 meters above sea level.

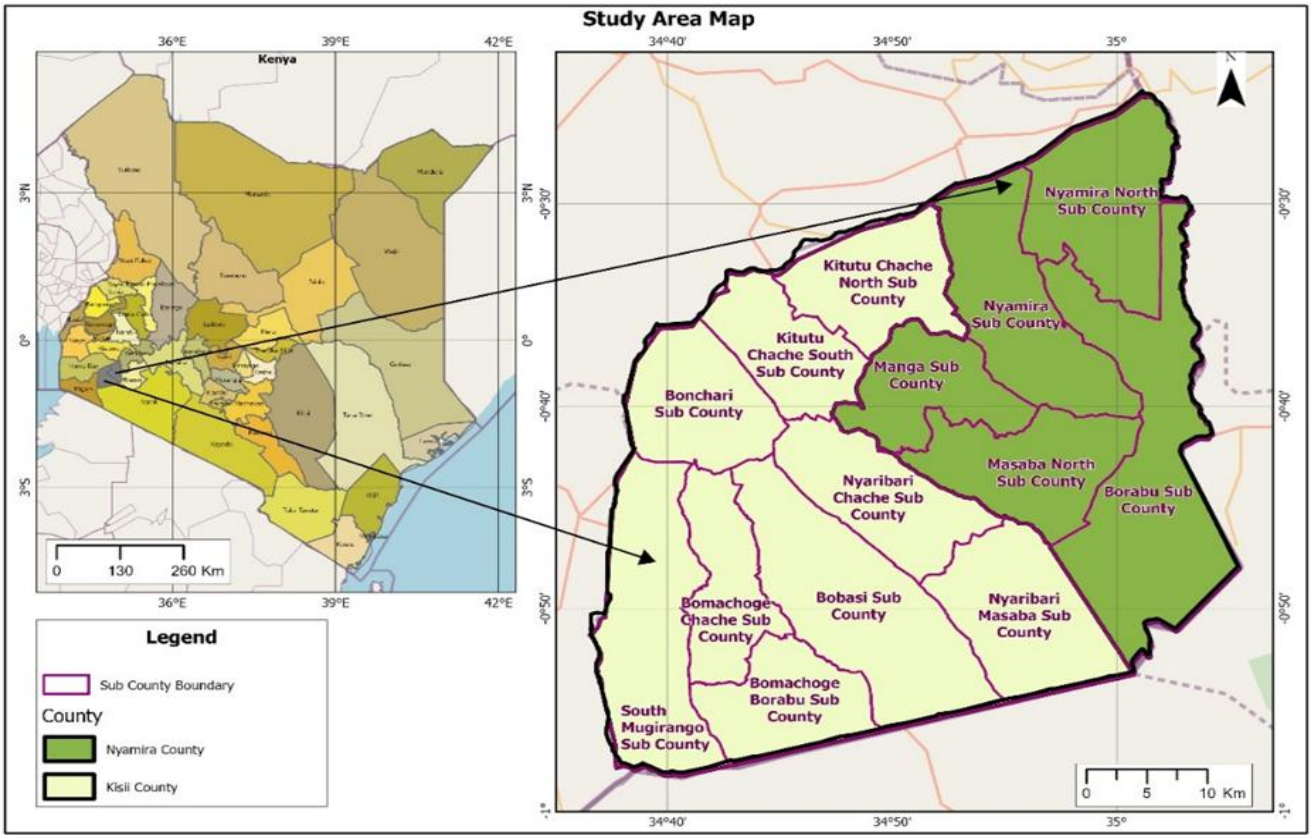

Fig 1: Study Area Map of Kenya showing Kisii and Nyamira Counties

Kisii County, has a population size of about 1,266,860 people (308,054 households), according to Kenya National Bureau of Statistics (2019) [6]. It enjoys a favorable agricultural climate, receiving 1,500-1,800 mm of bimodal annual rainfall (long rains from March to June and short rains from October to December).

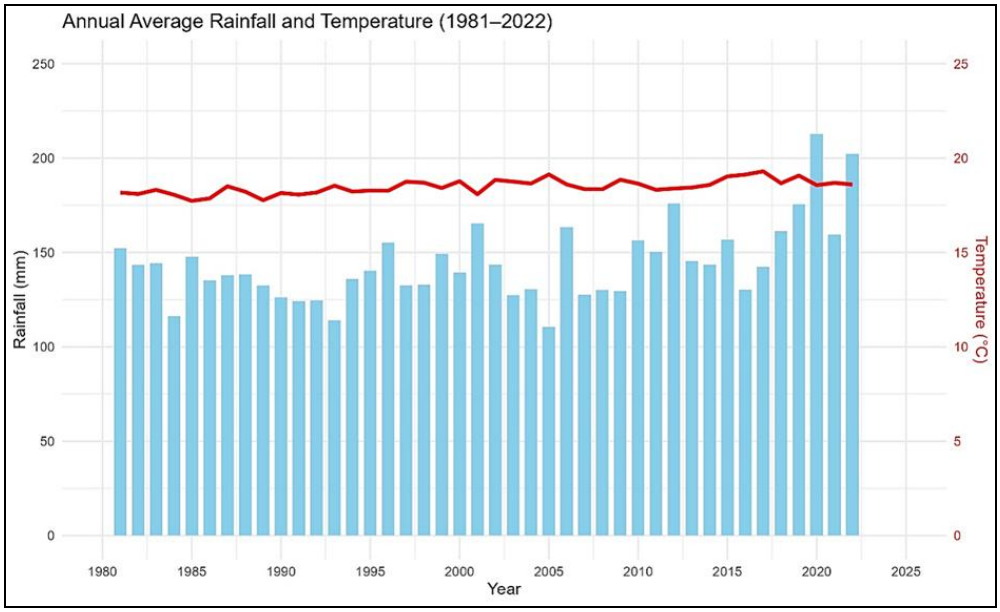

Fig 2: Shows the annual average rainfall and temperature (1981-2022)

The county's well-drained, fertile red volcanic soils support diverse agricultural activities, while short rains occur from September to November, with temperatures ranging between 15°C and 25°C. Agricultural activities supported are tea, coffee, banana, and sugarcane farming. The dense vegetation includes both indigenous and exotic trees, and the area is well-drained by rivers and streams like the Kuja River, which is essential for irrigation and subsistence needs.

Nyamira County, on the other hand, has an estimated population of 605,576 people (150,669 households). It covers a total area of approximately 912.5 km² and receives 1500-1800 mm of bimodal annual rainfall. Temperatures range from 14°C to 26°C. The fertile, well-drained volcanic soils support various farming activities such as tea farming and sugarcane cultivation, among others. The vegetation includes natural forests and tea plantations. The study focuses on the dry season (January-February) and the wet season (March-May) to capture seasonal variations in climate impacts.

3.2 Research Design and Sampling Techniques

This study adopted a descriptive research design, integrating both quantitative (structured surveys) and qualitative (in-depth interviews, focus group discussions (FGDs), and participant observation) methods. This mixed-methods approach provided a comprehensive understanding of the linkages between climate variability, domestic water resources, and household livelihoods. A cluster random sampling method was employed to ensure proportional representation of households within the areas of study. Sub-counties served as clusters. Within each sub-county, households were randomly chosen using a systematic approach (transect walk within all the cardinal compass directions). This approach ensured an unbiased, balanced, and fair selection process. The target population consisted of all households in Kisii and Nyamira counties, totaling 458,719 households. To determine the sample size, (Mugenda and Mugenda, 2003) [8], The formula for finite populations was used, resulting in an estimate of 384 households. To account for potential non-response, a 10% buffer was included, increasing the sample size to a total of 422 households in both counties.

3.3 Since the Kisii and Nyamira population (N) is finite (458,719 households)

$$\text{nadj} = \frac{n}{1 + \frac{n-1}{N}}$$

Where,
Nadj is the adjusted sample size,
N is the initial sample size calculated.
N is the population size.
Substituting n=384 and N=458,719:
nadj=384/(1+(384-1)/458,719)
nadj≈ 383.67

A pilot study was conducted with 20 households (10 from each county) to refine the questionnaire and improve data collection. After the pilot study, the final data collection involved distributing the refined questionnaires in each county across the selected 14 Sub-Counties, nine (9) from Kisii and five (5) from Nyamira. This ensured diverse representation and comprehensive coverage.

The total households per sub-county was first aggregated administratively from the Sub-County data as provided by the Kenya National Bureau of Statistics (2019) [6] census report. The number of questionnaires distributed per sub-county was based on the total number of households per sub-county, with sub-counties having a higher number of households receiving more questionnaires (Table 1). This iterative approach ensured that the final sample size was sufficient to comprehensively cover the research objective. The calculation was based on a ratio expression, as given in the equation below;

$$Questionnaires\ per\ subcounty = \frac{Total\ Households\ per\ subcounty}{Total\ Households} \times Total\ sample\ size$$

Table 1: Household distribution and average questionnaires per sub-county in Kisii and Nyamira Counties

County	Sub-County	Number of Households	Average Questionnaires
Kisii	Bobasi	46,370	38.8
	Bonchari	31,696	26.5
	Bomachoge Chache	39,389	33
	Bomachoge Borabu	30,989	25.9
	Kitutu Chache North	26,186	21.9
	Kitutu Chache South	41,271	34.5
	Nyaribari Chache	44,311	37
	Nyaribari Masaba	29,232	24.4
	South Mugirango	18,610	15.6
Total (Kisii)		308,050	257.6 (avg)
Avg HH size			4.1
Nyamira	Manga	23,869	19.9
	Nyamira North	40,446	33.9
	Nyamira South	38,973	32.7
	Borabu	19,468	16.3
	Masaba North	27,913	23.4
Total (Nyamira)		150,669	126.23 (avg)
Avg HH size			4.0

Source: KNBS, 2019

3.4 Data Collection Procedures

Structured, closed-ended questions were used to gather data on the interactions between climate variability, domestic water resources, and household livelihoods. Pre-trained and qualified enumerators were used to collect quantitative data on household demographics, socio-economic status, sources and accessibility of domestic water, challenges related to quality and reliability, the impacts of climate variability on water availability, and the implications of these on household livelihoods. Additional questions assessed the adaptive strategies employed by households, their effectiveness, and the adequacy of support systems.

Key informant interviews targeted individuals with expert knowledge of local water management and livelihood systems. Focus group discussions (FGDs) were also held with selected groups from different sub-counties to capture their diverse opinions on water access, climate-related stress, and collective community adaptations.

To complement primary data, secondary data were sourced from reliable channels, including media outlets, research agencies, policy papers, government reports, academic publications, climate databases, and County Integrated Development Plans, to provide a well-rounded perspective on environmental, climatic, social, and economic sustainability issues. To validate the perceptions of the locals on climate variability, secondary data on rainfall and temperature were obtained from the government climate database, Kenya Meteorological Department (KMD), and anomalies were computed and presented. In addition to these methods, participant observation, photography, and video were also used where necessary to document real-time behaviors and conditions related to climate variability and water use. Data saturation was monitored to ensure comprehensive coverage of household experiences and livelihood responses to climate variability-induced water stress.

3.5 Data Analysis

To examine the nexus between climate variability, domestic water resources, and household livelihoods, both quantitative and qualitative techniques were applied. Quantitative data from household surveys were analyzed using SPSS version 27. Descriptive statistics (means, percentages, and frequency distributions) summarized household socio-economic characteristics, water access patterns, and livelihood dependencies.

To test associations between climate variability, water access, and livelihood outcomes, inferential statistics were employed. Chi-square tests and t-tests were applied to assess significant differences between households and across counties at 0.05 and 0.01 significance levels. Correlation analyses (Spearman's and Pearson's) were conducted to identify relationships between climate stressors (rainfall variability, drought, floods, cold seasons, and heat waves), domestic water resources, and livelihood indicators.

Principal Component Analysis (PCA) was applied to reduce dimensionality and generate composite indices, including climate-related indices (Rainfall-Drought-Heat Index, Drought-Heat-Cold Index, and Flood Index) and a combined livelihood index representing household livelihood outcomes. These indices were then used in regression models. Binary and multinomial logistic regressions examined how climate and water-related indices influenced household livelihood impacts and coping mechanisms. Multiple linear regressions specific to Kisii and Nyamira were further derived to quantify the contribution of climate variability and domestic water stress to variations in household livelihoods.

Qualitative data from key informant interviews, FGDs, and participant observation were thematically analyzed to complement quantitative results, highlighting community-level perceptions of climate variability, water resource challenges, and their implications for household livelihoods.

4. Results

4.1 Socio-demographic characteristics

A total of 422 questionnaires were administered, 20 of which were incomplete, and 9 were not returned. This translates to a response rate of 93.1%. meaning that a total of 393 individuals were recruited for this study, comprising 261 were from Kisii County and 132 were from Nyamira County. The majority (47.6%) of them were aged between 31 and 50 years.

Table 2: Demographic characteristics of respondents in Kisii and Nyamira Counties

Characteristic		County		Chi-square Comparison
	Overall	Kisii	Nyamira	*p*-value
Age	**N=393**	**N=261**	**N=132**	**0.815**
18–30 years	90 (22.9%)	62 (23.8%)	28 (21.2%)	
31–50 years	187 (47.6%)	124 (47.5%)	63 (47.7%)	
Over 50 years	116 (29.5%)	75 (28.7%)	41 (31.1%)	
Gender	N=393	N=261	N=132	0.438
Male	196 (49.9%)	125 (47.9%)	71 (53.8) %	
Female	196 (49.9%)	135 (51.8%)	61 (46.2%)	
I prefer not to say	1 (0.2%)	1 (0.3%)	0 (0.0%)	
Household size	N=392	N=261	N=131	0.034
1-3 members	80 (20.4%)	63 (24.1%)	17 (13.0%)	
4-6 members	175 (44.7%)	110 (42.1%)	65 (49.6%)	
More than 6 members	137 (34.9%)	88 (33.8%)	49 (37.4%)	
Education level	N=393	N=261	N=132	0.150
No formal education	18 (4.6%)	11 (4.2%)	7 (5.3%)	
Primary	57 (14.4%)	35 (13.4%)	22 (16.7%)	
Secondary	183 (46.6%)	113 (43.3%)	70 (53.0%)	
Vocational/Technical training	68 (17.3%)	53 (20.3%)	15 (11.4%)	
Bachelors	64 (16.3%)	47 (18.0%)	17 (12.8%)	
Post-graduate	3 (0.8%)	2 (0.8%)	1 (0.8%)	
Years of residence	N=388	N=260	N=128	<0.001
Below 5 years	69 (17.8%)	59 (22.7%)	10 (7.8%)	
6-10 years	74 (19.1%)	55 (21.2%)	19 (14.8%)	

Young adults between the ages of 18 to 30 years constituted 22.9% of the total participants, and those over the age of 50 comprised 29.5%. A similar pattern of socio-demographic characteristics was noted in both counties (Table 2).

In terms of gender, the participants were evenly matched, with 49.9% identifying themselves as male and 49.9% as female; only 0.2% chose not to disclose their gender. In Kisii, female participants were 51.8%, slightly more than male participants (47.9%), whereas in Nyamira, there were a higher percentage of males (53.8%) than females (46.2%). These gender distribution differences were however not statistically significant (χ^2=1.651, DF=2, P=0.438) across the two counties (Table 4.1).

Most of the households had a household size of 4 to 6 members (44.7%), followed by larger households with more than 6 members (34.9%). Small-sized households with 1 to 3 members were reported by 20.4% of the total participants. Notably, Kisii had a significantly (χ^2=6.754, DF=2, P=0.034) higher percentage of small-sized households (24.1%) compared to Nyamira (13.0%) (Table 1).

When it comes to education, nearly half of the participants (46.6%) had completed secondary level, making it the most common level of education across Kisii and Nyamira counties. A small percentage of the participants had only primary education (14.4%), and 4.6% reported having no formal education. Very few participants (0.8%) had postgraduate qualifications. This trend was consistent in both Kisii and Nyamira counties (Table 2).

In relation to how long the participants had been living in their current residences, a significant majority (63.1%) of them had been there for over 11 years. Notably, more participants from Nyamira (77.4%) reported having lived in their homes for more than 11 years compared to Kisii participants (56.1%). On the contrary, Kisii had a higher number of newer residents, with 22.7% having lived there for less than 5 years, while just 7.8% of those in Nyamira reported a similar duration (Table 1).

4.2 Socio-economic characteristics

The leading main source of income among the participants was business, which accounted for 29.7%, followed by mixed farming at 23.0% and crop farming at 20.2% (Table 2). Formal employment, as an income source, was reported by 17.9% of the participants, while a smaller proportion relied on other sources (7.7%) and livestock rearing (1.5%). Although both Kisii and Nyamira participants had similar income trends, there were some notable differences. For instance, crop farming was a more prevalent mode of income in Nyamira (26.5%) than in Kisii (16.9%). On the other hand, formal employment was more prevalent in Kisii (20.4%) than in Nyamira (12.9%), (Table 3).

Table 3: Socio-economic characteristics of study participants in Kisii and Nyamira Counties

Characteristic		County		Chi-square comparison
	Overall	Kisii	Nyamira	
Main income source	N=392	N=260	N=132	0.116
Crop farming	79 (20.2%)	44 (16.9%)	35 (26.5%)	
Livestock rearing	6 (1.5%)	3 (1.2%)	3 (2.3%)	
Mixed farming	90 (23.0%)	64 (24.6%)	26 (19.7%)	
Business	117 (29.7%)	75 (28.8%)	42 (31.8%)	
Formal employment	70 (17.9%)	53 (20.4%)	17 (12.9%)	
Other sources	30 (7.7%)	21 (8.1%)	9 (6.8%)	
Total monthly income	N=382	N=258	N=124	0.756
Below KSh 10,000	105 (27.5%)	69 (26.7%)	36 (29.0%)	
KSh 10,001–20,000	156 (40.8%)	108 (41.9%)	48 (38.7%)	
KSh 20,001–50,000	94 (24.6%)	61 (23.6%)	33 (26.6%)	
Above KSh 50,000	27 (7.1%)	20 (7.8%)	7 (5.6%)	

In terms of income from the households, 40.8% of the participants, who comprised a larger percentage, earned between KSh 10,001 and 20,000 per month, followed by those earning less than KSh 10,000 (27.5%). A smaller percentage of the participants (7.1%) had a monthly income exceeding KSh 50,000. This income pattern distribution showed a considerable uniformity in both Kisii and Nyamira counties (Table 4.2). As over 68% of the respondents have an income of less than Ksh 20,000 a month, their economic constraints could be a limiting factor for them to implement successful measures in countering climate challenges.

4.3 Primary water sources, availability, accessibility and economic implications: The findings showed that springs were the primary source of water (64.1%), followed by shallow wells (8.9%), river water (7.1%), and boreholes (6.1%). Other sources included rainwater harvesting systems (6.7%), nearby tap water (5.1%), water vendors (1.5%) and a few dams/pans (0.5%) (Table 4). There was a statistically significant difference in how water sources were distributed between Kisii and Nyamira counties (χ^2=16.95, DF=7, P=0.018). In Nyamira, a higher percentage of participants (75.0%) relied on springs compared to just 58.6% of participants in Kisii. On the other hand, Kisii had a greater share of households using other sources of water, such as rivers (8.4%), boreholes (7.3%), shallow wells (10.0%), and rainwater harvesting (8.4%), compared to Nyamira (Table 4).

The report conducted showed that most participants (72.4%) reported accessing their primary water source within a distance of less than a kilometer from home, indicating relatively good physical access to water in both Kisii and Nyamira counties. However, about 23.5% had to travel between 1 to 5 kilometers, while smaller percentages traveled 5 to 10 kilometers (3.3%) and over 10 kilometers (0.8%) (Table 5). The pattern in distance to water sources was similar in both Kisii and Nyamira, signifying similar water access challenges.

Even though many participants lived close to these water sources, just over half (54.5%) confirmed that they had reliable access to water all year round. A significant number (45.5%) experienced intermittent or unreliable water supply. There was no significant difference in this regard between the two counties (χ^2=3.22, DF=1, P=0.57), (Table 3).

Table 4: Primary water sources, availability and accessibility, and economic implications

Characteristic		County		Chi-square Comparison
	Overall	Kisii	Nyamira	P-Value
Water sources	**N=393**	**N=261**	**N=132**	**0.018**
Springs	252 (64.1%)	153 (58.6%)	99 (75.0%)	
River	28 (7.1%)	22 (8.4%)	6 (4.5%)	
Boreholes	24 (6.1%)	19 (7.3%)	5 (3.9%)	
Shallow wells	35 (8.9%)	26 (10.0%)	9 (6.8%)	
Rainwater harvesting	26 (6.7%)	22 (8.4%)	4 (3.0%)	
Water vendors	6 (1.5%)	5 (1.9%)	1 (0.8%)	
Nearby tap water	20 (5.1%)	14 (5.4%)	6 (4.5%)	
Dam/Pan	2 (0.5%)	0(0.0%)	2 (1.5%)	
Distance to water source	N=391	N=260	N=131	0.325
Less than 1 km	283 (72.4%)	188 (72.3%)	95 (72.5%)	
1-5 km	92 (23.5%)	60 (23.1%)	32 (24.5%)	
5–10 km	13 (3.3%)	11 (4.2%)	2 (1.5%)	
More than 10 km	3 (0.8%)	1 (0.4%)	2 (1.5%)	
Water consistently available throughout the year	N=391	N=260	N=131	0.57
Yes	213 (54.5%)	139 (53.5%)	74 (56.5%)	
No	178 (45.5%)	121 (46.5%)	57 (43.5%)	
Water source paid or not	N=388	N=258	N=130	0.676
Yes	64 (16.5%)	44 (17.1%)	20 (15.4%)	
No	324 (83.5%)	214 (82.9%)	110 (84.6%)	
Monthly expenditure on water	N=64	N=44	N=20	0.547
Below ksh. 500	21 (32.8%)	16 (36.4%)	5 (25.0%)	
501-1,000	26 (40.6%)	16 (36.4%)	10 (50.0%)	
1,001 – 2,500	12 (18.8%)	10 (22.7%)	2 (10.0%)	
2,501 – 5,000	5 (7.8%)	4 (7.5%)	3 (15.0%)	

In terms of cost, most participants (83.5%) did not pay for water access, while only 16.5% reported paying for it, and again, this pattern was consistent across the two counties. Among those who did pay for water, the majority (73.4%) spent KSh 1,000 or less each month (Table 5). This reflects a relatively low but varied financial burden for accessing water, as most households depend on communal or natural sources of water such as springs and rivers, which are typically free but can be unreliable during dry spells.

4.4 The Nexus between climate variability, water-related factors, and household livelihood: The objective examined the effects of climate variability, such as droughts, floods, and unpredictable rainfall, on household livelihoods in Kisii and Nyamira Counties, focusing on income, food security, health, and access to water resources, including availability and quality.

To properly examine the effects of climate variability and household water availability on household livelihoods, two distinct livelihood indices were first developed:

- The Livelihood Activity Impact Index, which consisted of variables related to crop production, livestock rearing, and farming water usage.
- The Livelihood Welfare Impact Index, which included variables on food security, household income, and health outcomes.

These indices were derived from relevant questionnaire items reflecting household perceptions of livelihood changes brought about by water stress and climate-related factors.

Table 5: Reflecting household perceptions of livelihood changes brought about by water stress and climate-related

Model	R	R^2	Adj. R^2	Std. Error	F-Value	P-Value
Kisii	0.339	0.115	0.093	1.05	5.1 (df1=6, df2=235)	<0.0001
Nyamira	0.417	0.174	0.131	0.66	4.03 (df1=6, df2=115)	0.001

Model summary Predictors: (Constant), REGR DistAccess and Water Quality, REGR Drought_heat_cold_index, REGR water_source_reliability, REGR Water_Availability_Index, REGR rainfall_drought_heat_index, REGR Flood_index

The ANOVA analysis confirms that the overall models are statistically significant in both counties (Kisii, F=5.101, p<0.0001 and Nyamira, F=4.028, P=0.001).

To reduce dimensionality and develop a unified measure representing overall livelihood impact, Principal Component Analysis (PCA) was performed on the two livelihood indices. The PCA results identified a single dominant component explaining a significant proportion of the variance, with strong loadings from both indices (component loadings of 0.676 and 0.736 for the Livelihood Activity and Welfare Impact Indices, respectively). The communalities for each index (0.458 and 0.542) revealed that the extracted component adequately represented the variance contained in the original indices. This combined livelihood index (CLI) was subsequently used as the dependent variable in regression analyses. Key predictor variables reflecting different dimensions of climate variability and water resource status were also developed through PCA from related questionnaire items. The Rainfall-Drought-Heat Index and Drought-Heat-Cold Index were constructed by grouping related climatic stress variables such as drought severity, heat waves, extreme cold seasons, and rainfall patterns. The Flood Index was

derived from measurements of flood severity and frequency. Household water experiences were measured using indicators such as the Water Availability Index, describing self-reported water availability and quality challenges; the Water Source Reliability and Cost Index, reflecting payment for water and consistency of supply; and the Water Distance, Access, and Quality Index, summarizing proximity to water sources and changes in water quality (Table 6).

Each predictor index was validated through factor loadings and communalities to ensure they effectively represented the underlying constructs of climate stress and water resource conditions as perceived by households. These indices were then incorporated as independent variables in multiple linear regression models to quantify their effects on the combined livelihood index, enabling a holistic understanding of how climate variability and water-related factors collectively influence household livelihoods in Kisii and Nyamira Counties.

Key Predictors of Livelihood Outcomes in Kisii County

Regression analysis in both counties offers valuable insights into the differences registered in the combined livelihood index, though with varying explanatory power.

The general multiple regression equation model used is shown below:

$$CLI=\beta_0 + \beta_1X_1 + \beta_2X_2 +...+ \beta_nX_n +...+ \varepsilon$$

Where,

CLI=Combined Livelihood Index, β_0=Constant (intercept), X_1, X_2,....., X_n=Predictor variables and β_1, β_2,……., β_n=Unstandardized regression coefficients (B values). ε=error term (captures variation in CLI not explained by X). The dependent variable is the combined livelihood index (CLI), derived from two underlying indices (Livelihood Activity Impact and Livelihood Welfare Impact), merged through Principal Component Analysis (PCA).

In Kisii county, the most influential and significant predictors of livelihood outcomes are Rainfall_Drought_Heat_Index (negative effect), Flood_Index (positive effect), and Water_Availability_Index (positive effect) (Table 6). As the exposure to the combined effects of rainfall variability, drought, and heat increases, livelihood outcomes decline (β=-0.171, P=0.007).

Table 6: Regression coefficients showing key predictors of livelihood in Kisii and Nyamira Counties

Predictors	B	β (Beta)	P-Value
Kisii County			
Rainfall_Drought_Heat_Index	-0.186	-0.171	0.007
Drought_Heat_Cold_Index	-0.071	-0.068	0.294
Flood_Index	0.142	0.133	0.033
Water_Availability_Index	0.195	0.188	0.003
Water_Source_Reliability_and_Cost	0.072	0.067	0.295
Distance_Access_Quality_Index	0.081	0.076	0.224
Nyamira County			
Rainfall_Drought_Heat_Index	-0.094	-0.113	0.204
Drought_Heat_Cold_Index	-0.048	-0.06	0.496
Flood_Index	0.122	0.16	0.077
Water_Availability_Index	-0.097	-0.12	0.174
Water_Source_Reliability_and_Cost	0.231	0.303	0.001
Distance_Access_Quality_Index	-0.037	-0.05	0.564

A positive coefficient for the Water Availability Index (β=0.188, P=0.003) shows that the livelihood outcomes (welfare, income, and food security) greatly improved with increased water availability. The livelihood outcomes in Kisii are not much affected by hot and cold extremes (β=-0.068, P=0.294), water source reliability and cost (β=-0.067, P=0.224), distance to water access and water quality (β=-0.076, P=0.224) (Table).

The regression equation model for Kisii county is as shown: It explains 11.5% of the total variance in livelihood outcomes (R^2=0.115, p< 0.001).

$$\mathbf{CLI_{Kisii}}=-0.003 + (-0.186) \times \text{Rainfall\_Drought\_Heat} + (-0.071) \times \text{Drought\_Heat\_Cold} + 0.142 \times \text{Flood} + 0.195 \times \text{Water\_Availability} + 0.072 \times \text{Water\_Reliability\_Cost} + 0.081 \times \text{Distance\_Access\_Quality} + \varepsilon$$

Where, $\varepsilon \sim N(0, 1.05)$.

For most households in Kisii, the low flood frequency and severity index recorded earlier in Table 4.4 indicates that flooding is rather rare and not severe for most of the families. That is, whenever they happen, the intensity is comparatively low and does not lead to major losses in livelihoods but may instead have temporary benefits such as increased soil water content in rainfed agricultural systems and recharging of the surface water sources. This is testified by the Flood Index positive regression coefficient (β=0.133, P=0.033) for Kisii county (Table).

Key predictors of livelihood outcomes in Nyamira County

Multiple linear regression analysis revealed, in Nyamira County, Water Source Reliability and Cost as a major and positive predictor of livelihood outcomes (β=0.302, P=0.001) (Table). This shows that greater reliability and cost-affordability of water sources are positively associated with household livelihood resilience or wellbeing in the region. Other climatic stressors did not significantly show any direct influence on livelihood outcomes in Nyamira County (Table 4.5). The regression equation model for Nyamira county is as shown: It explains 17.4% of the total variation in livelihood outcomes (R^2=0.174, P=0.001).

$$\mathbf{CLI_{Nyamira}} =-0.088-0.094 \times \text{Rainfall\_Drought\_Heat\_Index}-0.048 \times \text{Drought\_Heat\_Cold\_Index} + 0.122 \times \text{Flood\_Index}-0.097 \times \text{Water\_Availability\_Index}+0.231\times \text{Water\_Source\_Reliability\_Cost}-$$

$0.037 \times Distance\_Access\_Quality\_Index + \varepsilon$

Where $\varepsilon \sim N(0, 0.66)$.

5. Discussion

The findings demonstrate a strong nexus between climate variability, domestic water resources, and household livelihoods in Kisii and Nyamira Counties. Climate-related stressors, including rainfall variability, prolonged droughts, floods, cold spells, and heat waves, were shown to directly influence both the availability and reliability of domestic water supplies, which in turn shaped household livelihood outcomes. This aligns with earlier studies highlighting the centrality of water in linking climate variability to socio-economic vulnerability in rural African settings (IPCC, 2022; Mugambiwa & Tirivangasi, 2017) [4, 7].

5.1 Climate Variability and Domestic Water Stress

The study confirmed that households perceive rainfall patterns as increasingly unpredictable, a finding supported by rainfall and temperature anomalies from the Kenya Meteorological Department. Such erratic rainfall reduced water availability in rivers and springs, increased reliance on seasonal sources, and drove up water collection costs. Similar patterns have been reported in other highland regions of East Africa, where hydrological regimes are highly sensitive to climate fluctuations (Ongoma *et al*., 2018) [11]. The significant county-level differences in flooding were more acute in Kisii, while cold spells were more pronounced in Nyamira, highlighting the spatial heterogeneity of climate stressors even within a relatively small geographic region.

5.2 Water Stress and Household Livelihoods

Domestic water scarcity was shown to have far-reaching implications for livelihoods. The PCA-derived Livelihood Index indicated that water stress undermined agricultural productivity, livestock health, and non-farm activities like small-scale trade. These findings support the argument that water serves as a key livelihood asset within the Sustainable Livelihoods Framework (Scoones, 1998) [12], and its disruption threatens multiple livelihood pathways simultaneously. The gendered nature of water collection, with women bearing the greatest burden, further emphasizes the intersection between water access and household well-being (UN Women, 2021) [17].

5.3 Statistical linkages between climate, water, and livelihoods

The regression results confirmed that rainfall variability, drought, and floods were significant predictors of household livelihood outcomes, with notable county-level variations. These results reinforce the vulnerability framework (Turner *et al*., 2003) [15], which posits that exposure to hazards interacts with household sensitivity (e.g., landholding size, income levels) and adaptive capacity to shape livelihood outcomes. In Kisii, floods and rainfall variability were most damaging to livelihoods, consistent with the county's hilly topography that increases flood risks. Conversely, in Nyamira, droughts and cold spells were more critical, reflecting the county's greater reliance on rain fed agriculture and livestock.

6. Conclusion

This study examined the nexus between climate variability, domestic water resources, and household livelihoods in Kisii and Nyamira Counties. The results demonstrate that climate-related stressors, particularly rainfall variability, droughts, floods, extreme heat waves, and cold spells, exert significant pressure on domestic water resources, reducing availability, reliability, and quality. In turn, this water stress undermines household livelihoods by disrupting agricultural production, livestock health, and non-farm economic activities.

The analysis further showed that while households adopt various coping strategies, including water harvesting, purchase of water, crop diversification, and livestock destocking, most of these measures remain inadequate in the face of increasing climate variability. Regression results confirmed the strong statistical linkages between climate stressors, water access, and livelihood outcomes, with county-specific differences highlighting the need for localized adaptation strategies.

Therefore, the findings affirm that domestic water is a critical channel through which climate variability translates into livelihood vulnerability. Addressing climate-induced water stress is therefore central to safeguarding livelihoods in the Gusii Highlands.

7. Recommendations

- Strengthen climate-resilient water infrastructure through investing in rainwater harvesting systems, groundwater development, and water storage facilities to reduce household dependence on seasonal and unreliable sources, and expanding rural piped water schemes to ease domestic water access.
- Enhance early warning and climate information systems through strengthening the dissemination of climate forecasts at the county level to help households anticipate rainfall variability and plan water use, and integrating indigenous knowledge with scientific climate data to improve local relevance.
- Promote livelihood diversification and climate-smart Agriculture by supporting the adoption of drought-tolerant crops, water-efficient irrigation, livestock breeds adapted to variable climates, and encouraging income diversification through non-farm livelihood opportunities.
- Strengthen institutional and policy support through mainstreaming climate adaptation into County Integrated Development Plans (CIDPs) and enhancing collaboration between county governments, water authorities, Water Resources Users Associations (WRUAs), and local communities to implement inclusive water management strategies.
- Support community-based adaptation mechanisms by encouraging communal water-sharing schemes, rehabilitation of springs, protection of catchments, and empowering women and vulnerable groups who bear a disproportionate burden of water collection and climate-induced livelihood stress.
- Water projects should be periodically monitored and protected to prevent vandalism and stalling, thereby ensuring their continued contribution to household livelihoods

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