Original Research Article

Assessing the Effects of Climate Change on Human Security: Case of Nyahururu Sub-County, Laikipia County, Kenya

ABSTRACT

Climate change poses a significant threat to human security by exacerbating societal challenges, potentially leading to widespread despair. The primary objective of this study was to assess the effects of climate change on human security in Nyahururu Sub-County. The study adopted a concurrent triangulation research design. The study targeted the residents (household heads) of Nyahururu Sub-County, including farmers, pastoralists, ranchers and traders, who were distributed across the 4 locations/administrative units: Gituamba, Marmanet, Ngarua and Nyahururu. According to the Kenya National Bureau of Statistics, Nyahururu Sub-County had an estimated population of approximately 154,704 individuals and a total of 44,073 households as of the 2019 census. The study was conducted between 2021 and 2024. The study used both quantitative and qualitative methods. Data collection involved questionnaires, key informant interviews and focus group discussions, with stratified random sampling for household heads and purposive sampling for key informants. Data were analyzed using frequencies, percentages and thematic analysis. The study found that Nyahururu Sub-County experiences fluctuations in both temperature and precipitation levels from 1989 to 2023, with mean daily maximum temperatures ranging from 22.8°C to 24.4°C and total annual precipitation varying between 665.1 mm and 771.7 mm. These trends indicate climate variability rather than a consistent long-term change in either temperature or precipitation. The study recommends targeted interventions to enhance community capacity, strengthen governance structures and promote sustainable livelihoods to mitigate the impacts of climate change on human security.

Keywords: *Climate Change, Human Security, Nyahururu Sub-County, Sustainable Livelihoods, Resilience-Building*.

1. INTRODUCTION

Globally, climate change is widely acknowledged as the new norm around the world (Deafalla et al., 2021). Discourses at the national, regional and worldwide levels highlight the severe dangers that climate change poses to human life on earth. Humanity is in grave danger from the extensive and profound effects of climate change (Kumssa et al., 2021). Critical sectors of the economy, particularly in Africa, have been impacted by climate change. Climate change has triggered several human security threats, engendering a

multifaceted range of global challenges. Environmental displacement is a profound consequence of climate change, leading to the forced migration and displacement of vulnerable populations due to rising sea levels, extreme weather events and loss of habitable land (Thapa, 2021). This displacement not only disrupts communities but also exacerbates the scarcity of fundamental resources such as food and water. Food and water scarcity are amplified by alterations in weather patterns, diminishing agricultural productivity and contributing to malnutrition and water stress (Prabhakar, 2021). Moreover, climate-induced changes have been linked to conflict and instability, amplifying socio-political tensions and threatening regional peace and stability (Wolfram et al., 2019). The heightened frequency and intensity of extreme climate events escalate health risks, including the spread of diseases, malnutrition and mental health challenges due to traumatic experiences (Prabhakar, 2021). These events can trigger economic vulnerabilities by damaging infrastructure, reducing livelihood opportunities and increasing financial burdens for both individuals and governments (Wolfram et al., 2016).

In Africa, where rain-fed agriculture accounts for a significant portion of the region's principal sources of food and employment, the anticipated effects on food security are significantly greater and widespread (Bond, 2014). The effects of climate change in Africa intensify a situation already marred by civil wars and a population targeted by severe hunger (Said et al., 2019). Future survival will be challenging and expensive due to unpredictable weather patterns that reduce food supply and cause intense heat waves and flash floods. Hopelessness can easily be sparked anywhere in the world due to the relationship between climate change and deteriorating social situations (Paterson, 2020). In climate hotspots or third-world nations where there are few resources available to aid in coping or adaptation, the deteriorating state of climate change will probably be greater (Bond, 2014). Like other nations in the Horn of Africa, Kenya also suffers socioeconomic and political difficulties, such as widespread poverty, shoddy government, protracted wars, pressures from the population

and fast urbanization. M'mboroki et al. (2018) investigated how the personal conflict in Kenya is impacted by climate change. The findings indicated that resource-based conflicts in the nation are affected by climate change. According to the study, climate change is a stressor that exacerbates already existing tension over natural resources. The study demonstrates resource-based tensions as a personal conflict feature, but this aroused concerns about the likelihood of other personal conflict elements in Kenya.

In Laikipia County, which is one of the 47 counties of Kenya, a study conducted by Mutunga (2018) established that that agro-pastoralist disputes had been more frequent recently after a historical examination of the frequency of conflicts between pastoralists and farmers in the county. According to the study, the devastating impacts of drought connected to climate change are to blame for a surge in disputes over traditional herding sites in Laikipia county. In addition to droughts, climate change dangers also include floods, heat waves and wind. This illustrates the necessity of comprehending the effects of different risks on human security in Kenya. Therefore, additional research must be done to investigate the best strategies to address various facets of human security. Establishing the connections between climate change and threats to human security in Nyahururu Sub-County, Laikipia County, Kenya, raised a concern for the study. Despite the growing recognition of climate change impacts at a macro-level in Kenya, micro-level analyses specific to Nyahururu Sub-County remain scarce. Existing studies often overlook the intricate interplay between climate change, land cover changes and human security dynamics in this region (M'mboroki et al., 2018; Namenya et al., 2022). This research gap underscores the need for a comprehensive investigation into the localized effects of climate change on human security in Nyahururu Sub-County. Addressing this gap, this study aims to contribute valuable insights into the nuanced relationship between climate change and human security threats, informing targeted adaptation strategies and sustainable development initiatives in the region.

This research uses the environmental scarcity theory, which has been frequently employed in international studies since the 1990s, mainly to explain the occurrences of natural/environmental resource scarcities and the repercussions on humans. Homer-Dixon developed the concept of the environmental scarcity theory in relation to the environment and security. The fundamental tenet of this theory was developed on the broad premise that environmental devastation has the ability to lessen the distribution of vital wealth or resources. He pointed out that these shortages frequently impact communities in developing nations whose population heavily depends on these natural assets. Homer-Dixon investigated a number of situations in South Africa, Pakistan and Mexico to create the hypothesis of environmental scarcity. His research showed that when faced with the depletion of vital resources like land and water among others, human populations are obliged to move to more environmentally secure regions. Insecurity, racial tensions and the growth of violence were all sparked by the scenario of depleting resources (Homer-Dixon & Percival, 1995).

Homer-Dixon's environmental scarcity theory posits that the depletion and scarcity of fundamental resources, such as water, land and other vital wealth, can result in dire consequences for communities, especially in developing nations heavily reliant on these resources (Mahlakeng & Solomon, 2023). Environmental scarcity triggers a domino effect, intertwining insecurity, heightened tensions and the proliferation of violence. The theory explicates the vulnerabilities stemming from the depletion of essential resources, illustrating the subsequent social and geopolitical ramifications triggered by these shortages. Variables at play in this theory include the availability and depletion of resources, the subsequent forced population movements and the ensuing socio-political tensions borne from environmental insecurity (Robson, 2018). The theory underscores the critical interplay between environmental resources, human movements and resulting social instabilities, offering valuable insights into global security dynamics.

Homer-Dixon proposes three ways in which environmental scarcity manifests itself: demand-induced scarcity, in which accelerating population expansion and rising consumption raise resource demands (Ombara, 2021). Supply-induced scarcity is when the supply of resources for consumption declines and structural scarcity is when the allocation of a valuable resource is unfair or skewed. He claims that the three are incompatible with one another and frequently happen simultaneously. In particular, the case study of Nyahururu Sub-County, which has undergone continual deterioration and poses a threat to the human security of communities near forests as well as the entire country, shows how well Homer-Dixon's theory of environmental scarcity supports the research on climate change and human security (Makanga, 2019). Homer Dixon's environmental resource scarcity theory, thus, best reflects the problems and harmonizes with the study's main themes.

This theory is important in this study as it offers a comprehensive framework that provides valuable insights into the intricate relationship between environmental resource depletion and human security. Its strengths lie in its holistic approach, which encompasses various manifestations of scarcity, from demand-induced and supply-induced scarcities to structural inequities in resource distribution. Through addressing these multiple facets, the theory offers a comprehensive understanding of the diverse pathways through which environmental scarcity can impact human security. However, its weaknesses are often centred around the complexity of interpreting the interplay between environmental scarcity and resulting socio-political tensions. The theory does not consistently delve into the nuances and intricacies of the specific cultural and geopolitical landscapes, which could limit its applicability in certain contexts. Nevertheless, its relevance to the study of climate change and human security is profound, particularly in understanding the dynamics between resource depletion and social upheavals, providing a rich framework to analyze the threats posed by climate change in Nyahururu Sub-County and other similar regions.

Existing studies provide critical insights into the effects of climate change on human security (Panagos et al., 2017; Borrelli et al., 2017; Grill et al., 2019). It emphasizes the limitations of current global models in predicting soil erosion due to water, highlighting the reliance on outdated climatic assumptions and coarse-scale data (Panagos et al., 2017; Borrelli et al., 2017). The study by Borrelli et al. (2017) and others underscore the need for refined, updated models to accurately assess soil displacement at finer scales, crucial for informing effective land use policies and sustainable management practices. Improved accuracy in predicting soil erosion not only aids in environmental planning but also indirectly contributes to human security by safeguarding livelihoods dependent on agriculture and natural resources in regions like Nyahururu Sub-County (Mwamba, 2019).

The review also discusses advancements and challenges in Geographic Information System (GIS)-based models like the Revised Universal Soil Loss Equation (RUSLE) (Mora et al., 2014; Njiru, 2012). It critiques previous projections for overestimating soil erosion rates due to outdated land use and climate data inputs (Mora et al., 2014; Ito et al., 2016). Recent advancements in remote sensing and earth observation technologies have enhanced the spatial resolution and accuracy of land cover products and climatic projections (Mora et al., 2014; Njiru, 2012). This progress is essential for refining models such as RUSLE to provide more precise estimates of soil erosion rates globally and locally, thereby supporting sustainable land management practices crucial for human security enhancement.

Namenya et al. (2022) study focuses on the micro-basin level impacts of climate variability on food security in Kenya, specifically in pastoralist communities. Their research highlights how changes in rainfall patterns and rising temperatures affect food availability and security indices. The study identifies rainwater harvesting as a viable strategy to mitigate the impacts of climate change on pastoralist and agro-pastoralist livelihoods, thereby enhancing food

security in the region. This local-level analysis underscores the importance of understanding climate variability's specific impacts on food production systems to bolster resilience and ensure human security in vulnerable communities like those in Nyahururu Sub-County.

In terms of understanding climate change and its impacts on human security, various studies have been conducted globally and within Kenya. These studies have provided substantial evidence of the existence of climate change and its multifaceted consequences on human societies. The Intergovernmental Panel on Climate Change (IPCC, 2021) has been instrumental in synthesizing scientific knowledge on climate change, highlighting its far-reaching implications for human well-being. Within Kenya, researchers have examined the effects of climate change on various sectors, including agriculture, water resources and health. For example, studies have shown how shifting rainfall patterns and rising temperatures have altered agricultural productivity and increased water scarcity in arid and semi-arid regions (Namenya et al., 2022). Moreover, the prevalence of climate-related disasters such as droughts and floods has exacerbated food insecurity and livelihood vulnerabilities among vulnerable communities as shown in LCG reports, 2017–2022.

However, despite these efforts, there remains a notable gap in research focusing on micro-level climate change impacts and adaptation strategies, particularly in regions like Nyahururu Sub-County. While macro-level studies provide valuable insights into broader trends and patterns, they often fail to capture the localized nuances and complexities of climate change impacts on human security (M'mboroki et al., 2018). In Nyahururu Sub-County, where communities rely heavily on agriculture and pastoralism for their sustenance, understanding these localized impacts is crucial for developing context-specific adaptation measures and resilience-building strategies (Namenya et al., 2022). Therefore, this research project sought to address this gap by conducting an in-depth investigation into the the effects of climate change on human security in Nyahururu Sub-County, Laikipia County, Kenya. This study

aimed to assess the effects of climate change on human security in Nyahururu Sub-County, Laikipia County, Kenya.

2. MATERIAL AND METHODS

The research aimed to investigate the impact of climate change on human security in Nyahururu Sub-County, Laikipia County, Kenya, using a concurrent triangulation mixed-methods design. This study was conducted in Nyahururu Sub-County, situated within Laikipia County, Kenya. The Sub-County lay between latitude: 0° 2' 6.5904'' N and longitude: 36° 21' 51.4512'' E, covering an area of approximately 813.4 km² and a population of 154,704. The sub-county shared borders with other sub-counties including Ndaragwa Sub-County, Laikipia East Sub-County and Laikipia West Sub-County. The region experienced a relief rainfall pattern, with an average annual rainfall ranging from 400 mm to 750 mm. The annual average temperature fluctuated between 16°C to 26°C.

The study targeted a diverse population of 44,073 households across four administrative units (Gituamba, Marmanet, Ngarua and Nyahururu), employing stratified random sampling for household heads and purposive sampling for key informants. Using Kothari (2004) formula, a total of 99 respondents were sampled. Data collection methods included hydrometeorological data, structured questionnaires, key informant interviews and focus group discussions (FGDs), supplemented by secondary data from literature and document reviews. Pilot testing ensured the clarity and reliability of the instruments, achieving a Cronbach's alpha of 0.852. Data analysis combined descriptive statistics for quantitative data (frequencies and percentages) and thematic analysis for qualitative data to explore climate change trends, their effects on human security and the effectiveness of adaptation strategies. The study adhered to legal and ethical standards, obtaining informed consent and maintaining confidentiality, ensuring participants' privacy and cultural sensitivity.

3. RESULTS AND DISCUSSION

3.1 Response Rate

The study aimed to collect data from 99 respondents, including 14 household heads from Gituamba, 18 from Marmanet, 18 from Ngarua and 49 from Nyahururu. However, some questionnaires were incompletely filled out and thus excluded from the final data analysis. Specifically, 12 household heads from Gituamba, 15 from Marmanet, 17 from Ngarua and 43 from Nyahururu completed the questionnaires in full, resulting in a response rate of 87.9% and a non-response rate of 12.1%. These responses were deemed eligible for inclusion in the research. Table 1 presents the response rates for each administrative unit. This shows that the study had a varied distribution of respondents across different administrative units within Nyahururu Sub-County.

Table 1: Response Rate

Administrative Units	Sample Size	Response rate (n)	Response (%)
Gituamba	14	12	85.7
Marmanet	18	15	83.3
Ngarua	18	17	94.4
Nyahururu	49	43	87.8
Total	99	87	87.9

The response rate of 87.9% reflects a commendable effort to gather data from a diverse population across Nyahururu Sub-County. However, achieving a 100% response rate is often difficult due to factors specific to the region and the nature of the respondents. For instance, household heads in Gituamba, Marmanet, Ngarua and Nyahururu may have faced challenges such as conflicting schedules, limited availability, or even reluctance to participate in the study. Although the research team likely made multiple attempts to follow up with non-respondents through repeated visits or phone calls, logistical issues such as the dispersed nature of rural households, transport difficulties and respondents' other responsibilities can limit the effectiveness of these efforts. Furthermore, incomplete questionnaires, as seen in the study, indicate that some participants may have started the

survey but were unable to complete it due to misunderstandings or fatigue. While a higher response rate is always desirable, practical constraints often prevent surveys from reaching full participation and the 87.9% achieved is still well within acceptable limits for robust data analysis.

3.2 Effects of Climate Change on Human Security in Nyahururu Sub-County

3.2.1 Trends in Temperature

The historical meteorological records were obtained from the Kenya Meteorological Department (KMD) and include data on mean daily maximum temperature (°C), mean daily minimum temperature (°C) and total annual precipitation (mm) spanning from 1989 to 2023. The mean daily maximum temperature ranged from 22.8°C to 24.4°C, while the mean daily minimum temperature ranged from 16.0°C to 16.9°C over the observed years. A slight fluctuation in temperatures can be observed, with some years experiencing slightly higher maximum temperatures compared to others. However, there is no clear overall trend of temperature increase or decrease over the period.

During the first decade from 1989 to 1999, the linear trend lines for Mean Daily Maximum Temperature (°C) and Mean Daily Minimum Temperature (°C) showed a slight increase, indicating a gradual rise in both maximum and minimum temperatures. This suggests a subtle but notable warming trend during this period. Moving to the second decade spanning from 2000 to 2009, the trends in temperature escalated more prominently. The linear trend lines for Mean Daily Maximum Temperature (°C) and Mean Daily Minimum Temperature (°C) depicted a notable increase compared to the previous decade. This indicates a more rapid warming trend, signifying potential intensification of temperature extremes. Entering the third decade, from 2010 to 2022, the temperature trends continued their upward trajectory, albeit at a slightly slower rate compared to the preceding decade. The linear trend lines for both Mean Daily Maximum Temperature (°C) and Mean Daily Minimum Temperature (°C) indicated a continued increase, albeit with some moderation. This

suggests a persistent warming trend, albeit with some fluctuations. The findings are shown in Figure 1.

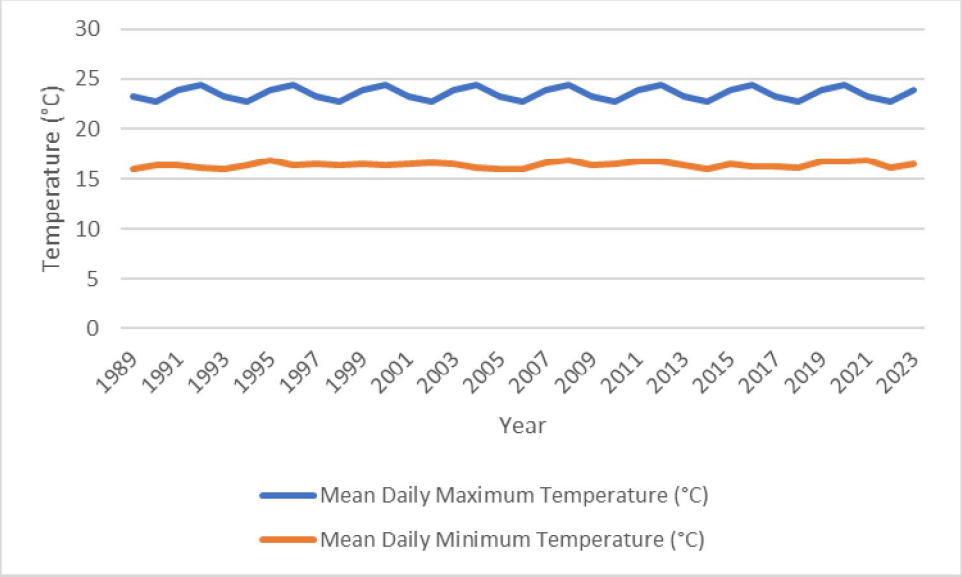

Figure 1: Trends in Temperature in Nyahururu Sub-County

Source: Kenya Meteorological Department

3.2.2 Trends in Rainfall

Total annual precipitation varied between 665.1 mm and 771.7 mm during the recorded years. Similar to temperature, there is no consistent trend in precipitation levels over time. Some years witnessed higher rainfall amounts, while others had comparatively lower levels of precipitation. This variability in rainfall indicates the presence of climate variability rather than a distinct long-term trend. The findings suggest that Nyahururu Sub-County experiences fluctuations in both temperature and precipitation levels over the years. These fluctuations may be influenced by various factors such as El Nino and La Nina events, as well as other regional climate phenomena.

Analyzing precipitation (rainfall) trends revealed varying patterns over the decades. During the first decade (1989-1999), the linear trend line for Total Annual Precipitation (mm) showed relatively stable precipitation levels with minimal fluctuations. This indicates a consistent rainfall pattern during this period. However, in the second decade (2000-2009), the trend in precipitation exhibited a slight decrease, as indicated by the downward slope of the linear trend line for Total Annual Precipitation (mm). This suggests a reduction in rainfall amounts compared to the previous decade, highlighting potential changes in precipitation patterns. Moving to the third decade (2010-2022), the precipitation trends showed a more erratic pattern, with fluctuations in rainfall levels over the period. The linear trend line for Total Annual Precipitation (mm) indicated variability in precipitation, with periods of increase and decrease. This suggests a less predictable rainfall pattern, potentially influenced by changing climate dynamics. The findings are shown in Figure 2.

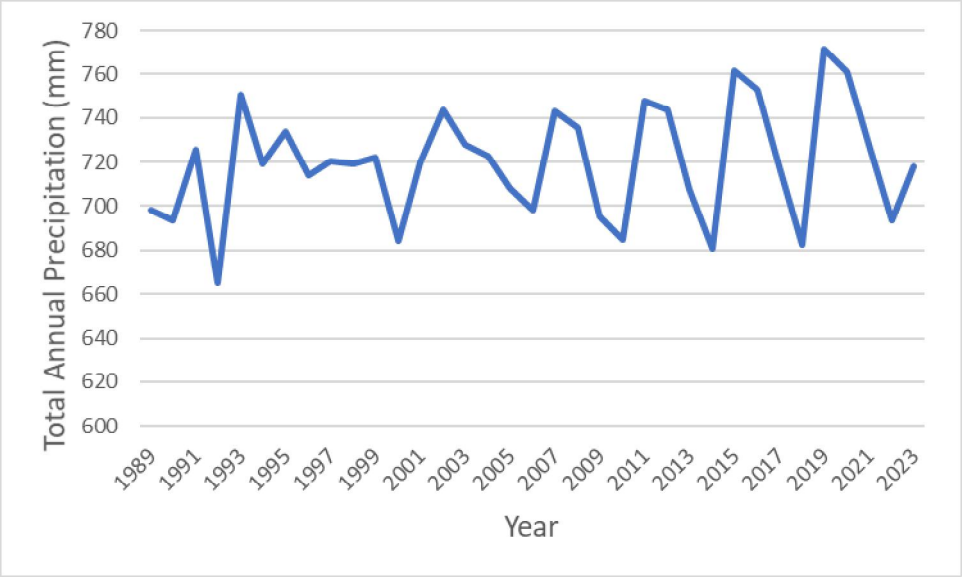

Figure 2: Trends in Rainfall in Nyahururu Sub-County

Source: Kenya Meteorological Department

3.2.3 Respondents' Perceptions on Trends of Climate Change

Based on the respondents' responses, the study sought to analyze the trends of climate change on human security in Nyahururu Sub-County over the past 30 years or more by examining various indicators related to climate change. For rainfall, 44.8% (n=39) of respondents reported an increase in rainfall over the last 30 years or more, 24.1% (n=21) reported a reduction, 21.8% (n=19) stated that rainfall has not changed and 9.2% (n=8) were unsure about the trend. Based on temperature, 37.9% (n=33) noted a decrease, 36.8% (n=32) observed an increase in temperature whereas 25.3% (n=22) reported no change. The findings are shown in Table 2.

Table 2: Respondents' Perceptions on Trends of Climate Change

		Increased (%)	Not changed (%)	Reduced (%)	Don't know (%)
Rainfall	F	39	19	21	8
	%	44.8	21.8	24.1	9.2
Temperature	F	32	22	33	0
	%	36.8	25.3	37.9	0.0

Key informants also highlighted that there were prolonged droughts and erratic rainfall patterns that have led to competition and disputes over limited water resources, particularly among pastoralist communities and farmers. Additionally, longed droughts and erratic rainfall patterns have led to changes in land cover and degradation of ecosystems that have intensified conflicts over grazing lands and agricultural areas. The following assertion was obtained to support these claims; "There are usually prolonged droughts and erratic rainfall patterns in Nyahururu area. We've seen an increase in conflicts between pastoralists and farmers over grazing lands and water points, especially during prolonged droughts. Climate change has made these resources scarcer, leading to more disputes" (Community leader).

3.2.4 Climate Change Variability and Human Security

For human-human conflicts, respondents illustrated that 65.5% (n=57) reported no change whereas 34.5% (n=30) of the respondents reported an increase. The research found that 78.2% (n=68) of the respondents observed an increase in human-wildlife conflicts whereas 21.8% (n=19) reported no change. On the other hand, 77.0% (n=67) reported an increase in banditry whereas 23.0% (n=20) reported no change in banditry. Furthermore, respondents indicated that 55.2% (n=48) observed an increase in theft incidences while 44.8% (n=39) about changes in theft incidences. From the findings, 78.2% (n=68) of the respondents reported an increase in crimes while 21.8% (n=19) reported no change in crimes. On the changes in protection to human rights, 65.5% (n=57) of the respondents reported an increase in protection to human rights, 21.8% (n=19) reported a reduction and 12.6% (n=11) were unsure about changes in protection to human rights. On the changes in land conflicts, respondents indicated that 55.2% (n=48) observed an increase in land conflicts whereas 44.8% (n=39) reported no change about changes in land conflicts (Table 3).

Table 3: Respondents' Perceptions on Human Security and Conflict

		Increased (%)	Not changed (%)	Reduced (%)	Don't know (%)
Human-human conflicts	F	30	57	0	0
	%	34.5	65.5	0.0	0.0
Human-wildlife conflicts	F	68	19	0	0
	%	78.2	21.8	0.0	0.0
Banditry	F	67	20	0	0
	%	77.0	23.0	0.0	0.0
Theft incidences	F	48	39	0	0
	%	55.2	44.8	0.0	0.0
Crimes	F	68	19	0	0
	%	78.2	21.8	0.0	0.0
Protection to human rights	F	57	0	19	11
	%	65.5	0.0	21.8	12.6
Land conflicts	F	48	39	0	0
	%	55.2	44.8	0.0	0.0
Fodder	F	18	58	11	0
	%	20.7	66.7	12.6	0.0
New diseases for livestock	F	48	39	0	0
	%	55.2	44.8	0.0	0.0
New diseases for human beings	F	49	19	19	0
	%	56.3	21.8	21.8	0.0
Health hazards	F	29	39	19	0

	%	33.3	44.8	21.8	0.0

The qualitative analysis also indicated that personal security is compromised as climate-induced hazards such as floods and landslides pose risks to life and property, especially in vulnerable communities residing in hazard-prone areas. Economic well-being is undermined by climate-related disruptions to livelihoods, particularly in the agricultural sector, where crop failures and livestock losses result in income shocks and poverty. Food security is threatened by decreased agricultural productivity, food shortages and rising prices, exacerbating hunger and malnutrition among vulnerable populations. Health security is compromised due to the proliferation of waterborne diseases, malnutrition and vector-borne illnesses resulting from changing climatic conditions. Additionally, environmental issues such as deforestation, soil degradation and water scarcity further compound human security challenges, exacerbating vulnerabilities and undermining resilience in the face of climate change, as shown in the following responses;

The increased frequency of extreme weather events like floods and droughts has left many families homeless and destitute, amplifying concerns about personal security and safety (CSO representative).

Smallholder farmers are grappling with declining crop yields and dwindling livestock populations, pushing them deeper into poverty and food insecurity (Security officer).

The prevalence of waterborne diseases such as cholera and typhoid is on the rise, posing significant health risks to communities already burdened by inadequate healthcare facilities and services (NGO representative).

Environmental degradation, including deforestation and soil erosion, threatens the sustainability of natural resources and undermines the long-term resilience of local ecosystems and communities ((CSO representative).

For fodder availability, 66.7% (n=58) reported no change, 20.7% (n=18) reported an increase in fodder availability while 12.6% (n=11) reported a reduction about changes in fodder availability. From the findings, respondents indicated that 55.2% (n=48) observed an increase in new diseases for livestock while 44.8% (n=39) reported no change in new diseases for livestock. For emergency of new diseases for human beings, 56.3% (n=49) reported an increase in new diseases for human beings, 21.8% (n=19) reported no change, 21.8% (n=19) reported a reduction and 0.0% (n=0) were unsure about changes in new diseases for human beings. The findings indicated that 33.3% (n=29) observed an increase in health hazards, 44.8% (n=39) reported no change whereas 21.8% (n=19) reported a reduction on changes in health hazards. The findings are shown in Table 3.

From the key informant interviews, open ended questions and FGDs, this includes investing in sustainable land management practices, improving water resource management and promoting biodiversity conservation. Capacity building efforts focusing on equipping communities with the necessary knowledge and resources to adapt to changing environmental conditions, such as providing training in climate-resilient agricultural techniques and disaster preparedness can be helpful. Additionally, fostering community engagement is essential for building resilience, as local knowledge and participation are key in developing effective climate change adaptation strategies.

In our community, unity and trust are crucial for addressing challenges like climate change and resource conflicts. When people are united, we feel safer and can work together effectively. But when there's tension and division, it's harder to tackle these issues, making us more vulnerable (Household head)

I've witnessed how social conflicts can escalate during instability. Divided communities are less likely to cooperate and more prone to violence or exploitation, posing a real threat to our well-being and security (CBO representative)

During times of social stability, our community networks and support systems are stronger. We can rely on each other for help and protection. However, when there's instability, these networks break down, leaving us more exposed to risks like poverty, displacement and exploitation (NGO representative).

3.2.5 Discussions

The findings resonate strongly with various themes presented in the literature while also revealing important nuances. The interplay of similarities and differences emphasizes the complexity of climate impacts on vulnerable communities. One significant alignment with existing research is the connection between climate change and resource conflicts. Bailey (2017) articulates how climate change exacerbates competition for natural resources, noting that shifts in weather patterns and environmental degradation intensify disputes over water and land among different stakeholders. This is echoed in the findings from Nyahururu, where increased competition for resources was a consistent concern among respondents. Similarly, Bond (2014) underscores the necessity of a holistic approach to address natural resource conflicts, a perspective that mirrors the qualitative findings attributing conflicts in Nyahururu to changes in land cover and ecosystem degradation. This alignment with the literature emphasizes the intricate relationship between climate change, resource competition and conflict dynamics in vulnerable regions.

The qualitative analysis also reveals critical implications of climate change for social stability and human security, resonating with the concerns raised by scholars like Kumssa et al. (2021) and Prabhakar (2021). The disruptions caused by climate-induced events—such as food insecurity, displacement and resource conflicts—parallel broader discussions on climate change impacts on vulnerable communities. This correspondence reinforces the literature's argument that climate change poses substantial threats to human security, underlining the importance of adaptive capacities in response to these challenges.

Moreover, the study highlights the role of governance in shaping vulnerability and resilience, aligning with Newell et al. (2021) and Paterson (2020), who recognize that inadequate governance structures and ineffective dispute resolution mechanisms hinder communities' adaptive efforts. In Nyahururu, respondents frequently cited governance issues as significant barriers to addressing the impacts of climate change, mirroring the literature's acknowledgment of governance as a crucial determinant of community resilience.

The findings also shed light on the differential impacts of climate change on pastoralist livelihoods, resonating with discussions by Njiru (2012) and M'mboroki et al. (2018). The heavy reliance of pastoralist communities on natural resources renders them particularly vulnerable to climate variability and extreme weather events, creating challenges in maintaining their traditional ways of life. This aligns with existing literature emphasizing context-specific approaches to climate adaptation, as the qualitative data capture the nuanced ways in which climate change intersects with socio-economic factors to shape vulnerability and adaptive strategies among these communities.

Theoretically, the findings align with the conceptual framework of human security articulated by Rosenzweig et al. (2018), which encompasses various dimensions such as economic, food, health, environmental and personal security. The qualitative data illustrate how climate change poses threats across these dimensions, highlighting its multifaceted impacts on individuals' well-being, livelihoods and safety. This comprehensive view reinforces the need for adaptive strategies and community-based interventions in preserving human security amidst climate change, reflecting the principles of resilience-building and sustainable development discussed in urban sustainability transitions literature (McCormick et al., 2013; Wolfram et al., 2016).

While these findings largely support existing literature on climate-induced conflicts, social vulnerability and adaptive strategies, they also reveal some notable divergences. One significant difference is the perception of temperature trends among respondents. While many studies indicate a steady increase in temperatures due to climate change, the findings from Nyahururu showed mixed perceptions, with a considerable portion of respondents reporting no noticeable changes. This discrepancy may arise from local climatic variability or differences in community awareness and experience.

Additionally, the emergence of human-wildlife conflicts, with 78.2% of respondents reporting such changes, points to a local dynamic that intensifies these issues. Although the literature acknowledges climate change's role in altering wildlife behavior, the extent of these conflicts in Nyahururu appears more pronounced than in other contexts, suggesting that unique local factors may exacerbate the situation.

4. CONCLUSION

The analysis of climate change trends in Nyahururu Sub-County highlights critical shifts that significantly impact human security. It is evident from both observed data and local reports that climate patterns are evolving, marked by an increase in extreme weather events such as droughts, floods and erratic rainfall. These changes disrupt traditional livelihoods, agricultural practices and water availability, creating substantial challenges for community well-being and resilience.

The implications of these findings extend across multiple dimensions of life in Nyahururu Sub-County. The effects manifest as food insecurity, water scarcity and increased vulnerability to natural disasters, while also heightening social tensions. The interconnectedness of these climate-related risks exacerbates existing vulnerabilities and compromises the overall safety and stability of local populations.

To mitigate the adverse effects of climate change on human security in Nyahururu Sub-County, targeted interventions by county governments, NGOs and community-based organizations (CBOs) are essential. This includes the development and implementation of climate-resilient infrastructure and the promotion of sustainable land and water management practices. Additionally, enhancing community-based early warning systems for climate-related hazards can significantly improve preparedness and response capabilities.

Capacity-building programs must also be prioritized to empower communities with the knowledge and skills required to adapt to changing environmental conditions effectively. Stakeholders can enhance resilience and foster a more secure future for Nyahururu Sub-County by equipping local populations to navigate the challenges posed by climate change. These strategies not only address immediate vulnerabilities but also contribute to long-term sustainable development in the region.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

REFERENCES

1. Bailey, T. (2017). Challenge and opportunity: Rethinking the role and function of developmental education in community college. *New directions for community colleges, 2009*(145), 11-30.

2. Borrelli, P., Robinson, D. A., Fleischer, L. R., Lugato, E., Ballabio, C., Alewell, C., . . . Ferro, V. (2017). An assessment of the global impact of 21st century land use change on soil erosion. *Nature communications, 8*(1), 1-13.

3. Deafalla, T. H., Csaplovics, E., Elkhair, O., & Abbas, M. M. E. (2021). The Effects of Land Cover Change on Sustainability: Human Security and Environmental Change in Semi-arid Ecosystems. In *Social-Ecological Systems (SES)* (pp. 137-158): Springer.

4. Frantzeskaki, N., Broto, V. C., Coenen, L., & Loorbach, D. (2017). *Urban sustainability transitions*: Routledge New York.

5. Grill, G., Lehner, B., Thieme, M., Geenen, B., Tickner, D., Antonelli, F., . . . Crochetiere, H. (2019). Mapping the world's free-flowing rivers. *Nature, 569*(7755), 215-221.

6. Ito, A., Nishina, K., & Noda, H. M. (2016). Impacts of future climate change on the carbon budget of northern high-latitude terrestrial ecosystems: an analysis using ISI-MIP data. *Polar Science*, *10*(3), 346-355.

7. Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

8. Kumssa, A., Williams, J., & Jones, J. (2021). *Conflict and Human Security in Africa*: Springer.

9. Makanga, C. M. (2019). *The Impact Of Environmental Factors On Human Security In Africa* (Doctoral dissertation, University of Nairobi).

10.Mahlakeng, M. K., & Solomon, H. (2023). Homer-Dixon's Environmental Scarcity Theory and Potential for Conflict in the Nile River Basin (NRB). In *African Security in the Anthropocene* (pp. 23-50). Cham: Springer Nature Switzerland.

11. M'mboroki, K. G., Wandiga, S., & Oriaso, S. O. (2018). Climate change impacts detection in dry forested ecosystem as indicated by vegetation cover change in Laikipia, of Kenya. *Environmental Monitoring and Assessment*, *190*(255), 1-19.

12. McCormick, K. anderberg, S., Coenen, L., & Neij, L. (2013). Advancing sustainable urban transformation. *Journal of cleaner production, 50*, 1-11.

13. Mora, B., Tsendbazar, N.-E., Herold, M., & Arino, O. (2014). Global land cover mapping: Current status and future trends. *Land Use and Land Cover Mapping in Europe*, 11-30.

14. Mutunga, V. M. (2018). *Natural Resource Management Framework as a Conflict Management Strategy in Kenya: A Case Study of Laikipia County.* University of Nairobi.

15. Mwamba, J. G. (2019). *Assessment of Peace Building Strategies Employed by The Presbyterian Church of East Africa in Enhancing Inter-Ethnic Harmony in Kenya* (Doctoral dissertation, Chuka University).

16. Namenya, N. D., Mugalavai, E. M., Mwendwa, K., Ouma, G., & Ouma, C. (2022). Dryland Pastoralism Climate Landscape and Food Security in the Suam River Basin of Kenya. *American Journal of Climate Change*, *11*(3), 173-196.

17. Newell, P., Paterson, M., & Craig, M. (2021). The politics of green transformations: an introduction to the special section. *New political economy, 26*(6), 903-906.

18. Njiru, B. N. (2012). Climate change, resource competition and conflict amongst pastoral communities in Kenya. In *Climate change, human security and violent conflict* (pp. 513-527): Springer.

19. Ombara, I. (2021). *Cross Border Natural Resource Management and Sustainable Peace in Eastern Africa Region: A Case Study of Kenya* (Doctoral dissertation, University of Nairobi).

20. Panagos, P., Borrelli, P., Meusburger, K., Yu, B., Klik, A., Jae Lim, K., . . . Chattopadhyay, N. (2017). Global rainfall erosivity assessment based on high-temporal resolution rainfall records. *Scientific reports, 7*(1), 1-12.

21. Paterson, M. (2020). Climate change and international political economy: Between collapse and transformation. *Review of International Political Economy, 28*(2), 394-405.

22. Percival, V., & Homer-Dixon, T. F. (1995, October). *Environmental scarcity and violent conflict: the case of South Africa.* Washington: American Association for the Advancement of Science.

23. Prabhakar, S. (2021). Policies and institutions shaping human security in an era of changing climate and increasing disasters. In *Climate Change, Disaster Risks and Human Security* (pp. 57-84): Springer.

24. Rawat, P. K., Tiwari, P. C., & Pant, C. C. (2012). Climate change accelerating land use dynamic and its environmental and socio-economic risks in the Himalayas: Mitigation through sustainable land use. *International Journal of Climate Change Strategies and Management*.

25. Robson, C. (2018). *Real-world research: A resource for social scientists and practitioner-researchers*. Wiley-Blackwell.

26. Rosenzweig, C., Solecki, W. D., Romero-Lankao, P., Mehrotra, S., Dhakal, S., & Ibrahim, S. A. (2018). *Climate change and cities: Second assessment report of the urban climate change research network*: Cambridge University Press.

27. Said, M., Komakech, H. C., Munishi, L. K., & Muzuka, A. N. N. (2019). Evidence of climate change impacts on water, food and energy resources around Kilimanjaro, Tanzania. *Regional Environmental Change*, *19*(1), 2521-2534.

28. Thapa, P. (2021). The Relationship between Land Use and Climate Change: A Case Study of Nepal. In *The Nature, Causes, Effects and Mitigation of Climate Change on the Environment*: IntechOpen.

29. Wolfram, M., Frantzeskaki, N., & Maschmeyer, S. (2016). Cities, systems and sustainability: Status and perspectives of research on urban transformations. *Current Opinion in Environmental Sustainability, 22*, 18-25.

30. Wolfram, M., Van der Heijden, J., Juhola, S., & Patterson, J. (2019). Learning in urban climate governance: concepts, key issues and challenges. *Journal of Environmental Policy & Planning, 21*(1), 1-15.

31. Yamane, T. (1967). *Research methods: determination of sample size*. University of Florida, IFAS Extension.