Effects of Climate Change on Land Use Patterns among Farmers and Pastoralists in Mvomero District, Tanzania

Athuman Ibrahim Mbarouk[1]*, Reguli Baltazar Mushy[2] and Emmanuel[3] Patroba Mhache
[1,2,3]*The Open University of Tanzania*
**Corresponding Author's E-mail: kimosha2017@gmail.com*

Abstract
Climate change continues to reshape land use systems globally, with rural communities in sub-Saharan Africa experiencing disproportionate impacts. This study examined how climate variability influences land use patterns and livelihood strategies among farmers and pastoralists in Mvomero District, Tanzania. Using a cross-sectional mixed-methods design, data were collected from 391 household heads selected through stratified random sampling and 26 purposively chosen key informants. Quantitative data were analyzed descriptively, while qualitative data were examined thematically. Findings indicate that prolonged droughts, erratic rainfall, and flooding have altered agricultural and pastoral practices, leading to shifts in cropping calendars, increased reliance on climate-smart agriculture, groundwater development, tree planting, and long-distance livestock mobility. These environmental stressors have intensified competition over land and water resources, contributing to recurrent farmer–pastoralist conflicts, displacement, and loss of property. The study concludes that climate change is a major driver of land use transformations in Mvomero District and recommends strengthened institutional frameworks, community-based adaptation, and integrated land use planning.

Keywords: *Climate change, Land use patterns, Farmers, pastoralists, adaptation, Mvomero District, Tanzania*

INTRODUCTION

Climate change has emerged as one of the most pressing global challenges of the 21st century, with profound implications for land use systems, food security, and rural livelihoods. Globally, rising temperatures, shifting precipitation patterns, and increased frequency of extreme weather events have disrupted agricultural production and pastoral mobility (IPCC, 2022). These climatic shifts have altered land suitability, reduced water availability, and intensified competition over natural resources, particularly in developing countries where livelihoods

depend heavily on climate-sensitive sectors. At the regional level, sub-Saharan Africa is considered highly vulnerable due to its reliance on rain-fed agriculture and extensive pastoralism. Studies across East Africa show that prolonged droughts, unpredictable rainfall, and recurrent floods have contributed to declining crop yields, rangeland degradation, and increased pastoral migration (Nkiaka et al., 2020; Gebremeskel et al., 2021). These changes have heightened tensions over land and water resources, especially in areas where farming and pastoralism coexist.

In Tanzania, agriculture accounts for more than 26% of GDP and employs over 65% of the population, making climate change a significant threat to national development (URT, 2023). The country has experienced recurrent droughts, floods, and temperature increases that have disrupted farming systems and pastoral mobility. Several districts in Morogoro Region including Kiroka, Mkindo, and Njage have been documented as climate-change hotspots due to frequent flooding, crop losses, and water scarcity (TMA, 2022). Despite these challenges, limited empirical research has examined how climate variability specifically shapes land use patterns among farmers and pastoralists in Mvomero District. Mvomero District is characterized by a long history of farmer-pastoralist interactions, recurrent land use conflicts, and climate-induced migration. Although the district has benefited from national initiatives such as Village Land Use Plans (VLUPs), the Environmental Management Act (2004), decentralized climate adaptation funds, and village by-laws, the effectiveness of these interventions remains unclear. Existing reports indicate persistent disputes over grazing areas, farmland expansion, and water access, suggesting gaps in land governance and climate adaptation mechanisms (MLHHSD, 2021).

Despite the growing body of literature on climate change and land use in Tanzania, several gaps remain. First, most studies focus on either agricultural impacts or pastoral mobility, with limited attention to how both systems interact under climate stress. Second, few studies integrate local perceptions with empirical evidence to explain how climate variability shapes land use decisions. Third, there is limited contextual analysis of Mvomero District, despite its documented vulnerability and history of resource-based conflicts. This study addresses these gaps by examining how climate change affects land use patterns and livelihood strategies among farmers and pastoralists in Mvomero District. Specifically, the study aims at assessing the major climate-related

environmental stressors affecting land use, examining how farmers and pastoralists have adjusted their land use practices in response to climate variability, and analyzing the implications of climate-induced land use changes for local livelihoods and human security. By integrating quantitative and qualitative evidence, the study contributes to ongoing debates on climate adaptation, land governance, and conflict mitigation in Tanzania.

LITERATURE REVIEW

Climate change has become a defining driver of land use transformations worldwide. Rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events have reshaped agricultural systems, rangelands, and settlement patterns (IPCC, 2022). Globally, farmers have been forced to modify cropping calendars, adopt drought-tolerant varieties, and shift from rain-fed to irrigated agriculture (Thornton et al., 2021). Pastoral communities, particularly in arid and semi-arid regions, have experienced shrinking grazing lands, reduced forage quality, and increased livestock mortality (Herrero et al., 2020). These changes have intensified competition over natural resources, contributing to land degradation, biodiversity loss, and resource-based conflicts.

Studies from Asia and Latin America show similar patterns. In India, climate-induced water scarcity has driven agricultural expansion into forest margins, increasing human-wildlife conflict (Kumar et al., 2020). In Brazil, prolonged droughts have accelerated deforestation as communities seek new agricultural land (Silva et al., 2021). These global findings highlight the interconnectedness of climate change, land use decisions, and livelihood vulnerability. Sub-Saharan Africa is widely recognized as one of the most climate-vulnerable regions due to its dependence on rain-fed agriculture and extensive pastoralism (Nkiaka et al., 2020). Across East Africa, prolonged droughts have reduced pasture availability, forcing pastoralists to migrate over longer distances and into farming zones (Gebremeskel et al., 2021). In Kenya, climate variability has contributed to recurrent farmer-herder conflicts in Turkana, Baringo, and Laikipia, where competition over water and grazing land has intensified (Mkutu, 2020). Similar patterns have been observed in Ethiopia, where pastoral mobility has increased due to rangeland degradation and water scarcity (Teshome et al., 2022). In Uganda, flooding and erratic rainfall have altered cropping systems, leading to

expansion into wetlands and forest reserves (Nsubuga & Namutebi, 2021). These regional studies demonstrate that climate change is reshaping land use patterns through both ecological stress and human adaptation strategies.

Tanzania has experienced significant climate variability over the past three decades, including rising temperatures, recurrent droughts, and unpredictable rainfall (TMA, 2022). These changes have affected agricultural productivity, pastoral mobility, and land governance. National reports indicate that climate change has contributed to declining crop yields, increased livestock mortality, and expansion of farming into marginal lands (URT, 2023). Several areas in Morogoro Region-such as Kiroka, Mkindo, and Njage have been identified as climate-change hotspots due to frequent flooding, soil erosion, and water scarcity (Morogoro Regional Secretariat, 2022). Despite this, limited empirical research has examined how climate variability specifically influences land use patterns in Mvomero District, which has a long history of farmer-pastoralist interactions. Tanzania has implemented several policy initiatives to address climate-related land use challenges, including village land use plans (VLUPs) to guide land allocation and reduce conflict, environmental management Act (2004) to regulate resource use, national climate change strategy (2021-2026) promoting adaptation and resilience, decentralized climate adaptation funds supporting community-level initiatives, and village by-laws governing grazing, farming, and water access. However, studies show that these initiatives often face challenges such as weak enforcement, limited community participation, and inadequate institutional capacity (Kangalawe, 2020; MLHHSD, 2021). This raises questions about their effectiveness in districts like Mvomero, where climate-induced land use conflicts persist.

Existing literature consistently shows that climate change influences land use patterns through environmental stressors such as drought, flooding, and soil degradation. For example, Kashaigili et al. (2021) found that changes in rainfall and temperature patterns in Tanzania have altered cropping calendars and increased reliance on drought-tolerant crops. Msuya et al. (2020) reported that reduced pasture quality in semi-arid regions has forced pastoralists to migrate more frequently, increasing the likelihood of conflict with farmers. Studies from Nigeria, Ghana, and Sudan also show that climate-induced resource scarcity contributes to violent confrontations between farmers and pastoralists (Tonah, 2020;

Ofuoku & Isife, 2019). These conflicts often arise from crop destruction, livestock theft, and competition over water sources. While these studies provide valuable insights, most focus on either agricultural or pastoral systems in isolation. Few examine how both systems interact under climate stress, particularly in districts with complex land use histories like Mvomero.

Despite the growing body of literature, several gaps remain including limited integrated analysis of farming and pastoral systems where most studies examine either agricultural impacts or pastoral mobility, but not how the two systems interact under climate stress. Another gap is insufficient localized evidence from Mvomero District where although Mvomero is known for recurrent farmer-pastoralist conflicts, few studies have analyzed how climate variability specifically shapes land use patterns in this district. Weak linkage between national policies and local realities is another gap identified where existing research rarely evaluates how national initiatives such as VLUPs, EMA 2004, and climate strategies, influence land use decisions at village level. Also, there is limited use of mixed-methods approaches where studies combine quantitative household data with qualitative insights from key informants, which are essential for understanding complex land use dynamics. The last gap identified is lack of empirical evidence on human security implications where conflicts are documented, the specific ways climate-induced land use changes affect peace, safety, and livelihoods remain underexplored. The reviewed literature demonstrates that climate change is a major driver of land use transformations globally, regionally, and nationally. However, significant gaps remain regarding how climate variability affects land use patterns among farmers and pastoralists in Mvomero District. This study addresses these gaps by providing an integrated, mixed-methods analysis of climate-induced land use changes and their implications for livelihoods and human security.

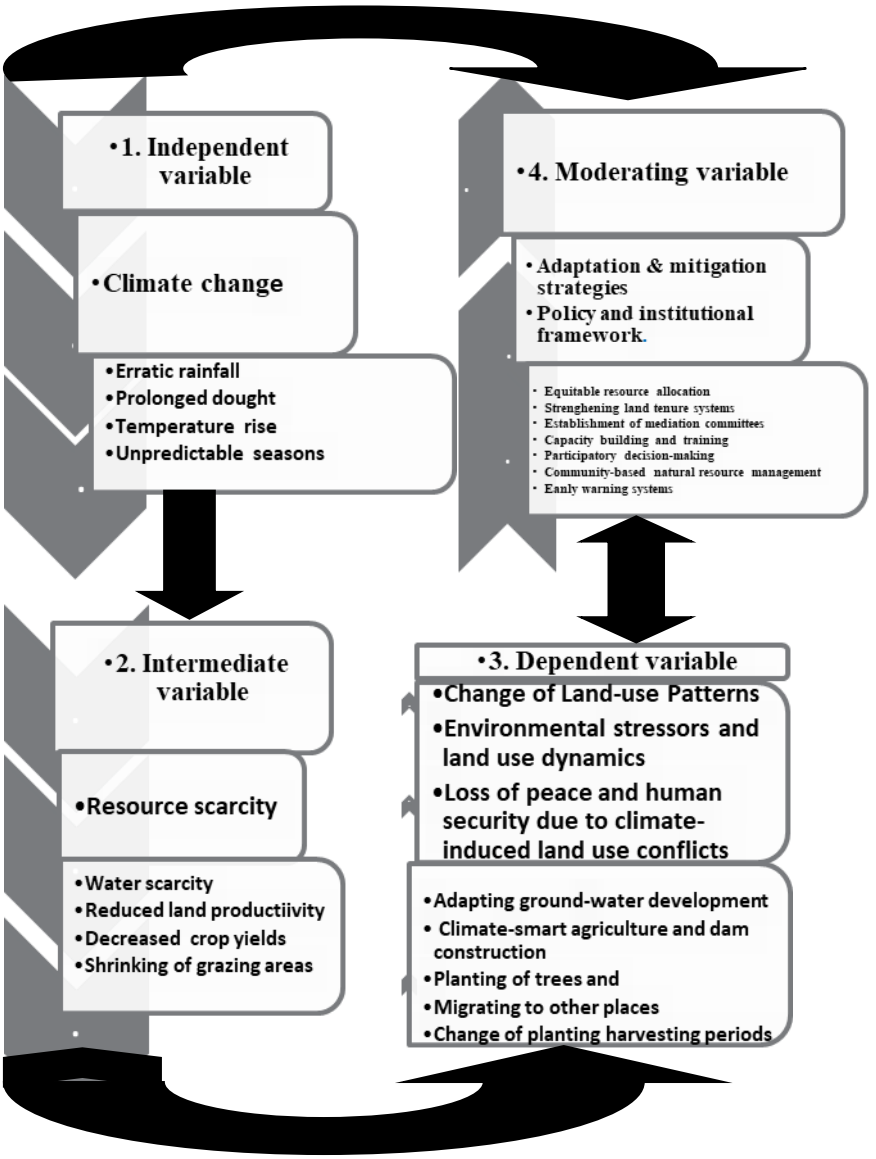
Understanding how climate change influences land use patterns among farmers and pastoralists requires a framework that links environmental stressors, resource dynamics, human responses, and institutional conditions. The conceptual framework guiding this study is grounded in climate-livelihood interaction theory and empirical evidence from global and regional studies. The framework illustrates how climate change acts as a primary driver, triggering a chain of ecological and socio-economic responses that ultimately reshape land use patterns in Mvomero District.

It also identifies intermediate variables that mediate these relationships and moderating variables that influence the extent of their effects.

Climate change is conceptualized as the overarching independent variable influencing land use decisions. Based on global and regional literature (IPCC, 2022; Nkiaka et al., 2020), the study focuses on four major climate-related stressors including prolonged droughts which leads to reduced water availability, dry up grazing lands, and lower soil moisture, affecting both crop and livestock productivity.

Other major climate-related stressors include erratic rainfall which shortens planting seasons, disrupts agricultural calendars, and increases uncertainty in land preparation, flooding which damages crops, destroys infrastructure, and forces temporary or permanent relocation, and temperature rise which accelerates evapotranspiration, reduces soil fertility, and alters vegetation composition in rangelands. These stressors create ecological pressure that directly affects land availability, productivity, and suitability for farming or grazing. The effects of climate change on land use are not direct; they operate through several mediating variables that shape how communities respond including resource scarcity where climate stress reduces the availability of water sources, pasture and forage, and fertile agricultural land. This scarcity forces both farmers and pastoralists to modify their land use practices.

Figure 1:
Effects of climate change on land-use patterns



Key: ➡ Forward relationship, ⟷ Backward and forward relationship
Source: Researcher (2024)

As drought intensifies and pasture declines, pastoralists increase the distance and frequency of livestock movement. This mobility often brings them into farming zones, creating overlapping land claims. Resource

scarcity and mobility lead to expansion of farming into grazing lands, encroachment of livestock into cultivated fields, and use of forest reserves and marginal lands for survival. These overlaps heighten the risk of conflict and environmental degradation.

The relationship between climate stress and land use outcomes is influenced by institutional and socio-economic factors that can either mitigate or exacerbate the effects. These include policy and institutional frameworks such as Village Land Use Plans (VLUPs), Environmental Management Act (2004), National Climate Change Strategy, Village by-laws and Conflict resolution committees. Where these systems are strong, land use conflicts are minimized, and where they are weak, disputes escalate. Households and communities adopt various strategies such as climate-smart agriculture, groundwater development, tree planting, dam construction, diversification of livelihoods, and seasonal or permanent migration. These strategies influence how land is used and how communities cope with climate stress. Household income, education, livestock ownership, and access to extension services shape the ability to adapt and influence land use decisions. The combined effects of climate stressors, mediating factors, and moderating conditions result in observable changes in land use patterns, including shifts in cropping systems, expansion of farmland into new areas, increased pastoral mobility, use of forest reserves and marginal lands, intensification of land use competition, and increased frequency of farmer-pastoralist conflicts. These outcomes directly affect livelihoods, human security, and environmental sustainability.

The conceptual framework in Figure 1 can be described as a forward-moving chain, where climate change introduces environmental stressors such as drought, erratic rainfall, flooding, and rising temperatures. These stressors create resource scarcity, reduce pasture and water availability, and degrade agricultural land. Resource scarcity triggers behavioral responses, including pastoral mobility, farmland expansion, and encroachment into shared or contested areas. The extent and nature of these responses are shaped by institutional and socio-economic moderators, such as land policies, adaptation strategies, and community governance structures. The interaction of these factors results in altered land use patterns, which may lead to conflict, displacement, or livelihood transformation. This framework aligns with

global climate-livelihood models and provides a structured lens for analyzing land use dynamics in Mvomero District.

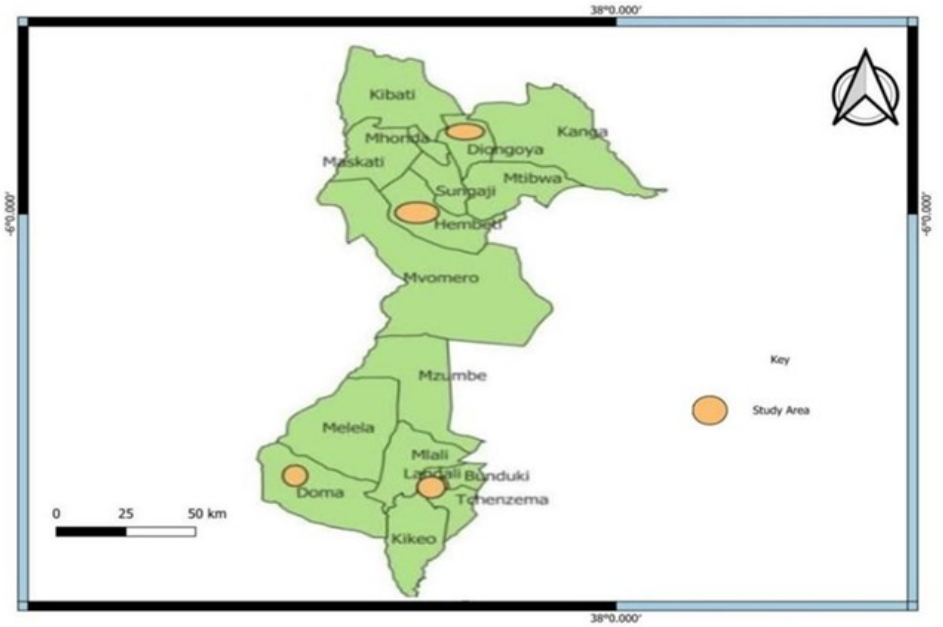
METHODOLOGY

This study adopted a cross-sectional mixed-methods design to examine how climate change influences land use patterns among farmers and pastoralists in Mvomero District. The cross-sectional approach enabled the researcher to collect data at a single point in time, capturing existing experiences, perceptions, and practices without implying temporal change. The mixed-methods design combined quantitative and qualitative techniques to enhance the depth, validity, and triangulation of findings.

The research was conducted in Mvomero District, Morogoro Region, Tanzania. The district is characterized by diverse agro-ecological zones that support both crop farming and livestock keeping. It has a long history of farmer-pastoralist interactions, climate-related stress, and recurrent land use conflicts. These characteristics make Mvomero an appropriate setting for investigating climate-induced land use dynamics. Four villages were selected for the study including Doma, Langali, Diongoya, and embeti. Doma and Langali are predominantly farming communities, while Diongoya and Hembeti are largely pastoralist. This variation provided a balanced representation of both livelihood systems. The villages were selected purposively based on the following criteria. Looking on high exposure to climate variability, the Mvomero District environmental reports identify these villages as experiencing recurrent droughts, erratic rainfall, and seasonal flooding, documented history of land use conflicts.

Previous studies by Kisoza, 2007; Mwamfupe, 2015, and district security records show frequent farmer-pastoralist disputes in these areas, and coexistence of farming and pastoralist communities. The study required villages where both groups interact and compete for land and water resources. Although other villages in Mvomero District such as Kiroka, Mkindo, and Njage, are also climate-affected, they were excluded because they do not exhibit the same intensity of farmer-pastoralist overlap as selected villages.

Figure 2
A Map of Mvomero District to a show the area of study



***Source**: Mvomero District Council Investment Profile (2024)*

The target population consisted of 16,675 household heads residing in the four selected villages. Additional participants included village leaders, agricultural and livestock officers, traditional leaders, and district officials who possess contextual knowledge of land use and climate-related challenges. A total sample of 415 participants was used in the study, comprising 391 household heads for the quantitative survey, and 26 key informants for qualitative interviews. The sample size for household heads was determined using Yamane's (1967) formula at a 95% confidence level and a precision level of 0.05:

[n = \frac{N}{1 + N(e^2)}]

Where: N = 16,675 , and

e = 0.05)

This yielded a sample of 391 respondents, which was considered adequate for statistical analysis. The additional 26 key informants were purposively selected based on their roles, experience, and relevance to the study. A stratified random sampling technique was used to select household heads. Each village formed a stratum, and the number of respondents drawn

from each village was proportional to its household population. This ensured fair representation of both farmers and pastoralists. While, purposive sampling was used to select 26 key informants, including Village chairpersons, Village Executive Officers (VEOs), Ward Executive Officers (WEOs), Agricultural and livestock officers, Security committee leaders, traditional leaders (Laigwanani/Laibon), District Executive Director (DED), and Officer Commanding District (OCD). Additionally, eight Focus Group Discussions (FGDs) were conducted, two in each village-separately for farmers and pastoralists.

Multiple data collection methods were used to enhance triangulation and validity. A structured questionnaire was administered to 391 household heads to collect quantitative data on climate change awareness, environmental stressors, and use practices, adaptation strategies, and livelihood impacts. The questionnaire included Likert-scale items, closed-ended questions, and a few open-ended items. Semi-structured interviews were conducted with 26 key informants to gather in-depth insights on historical land use changes, climate-related challenges, conflict dynamics, and institutional responses. Eight Focus Group Discussions (FGDs) (6–8 participants each) explored shared experiences and community perceptions of climate change and land use. Transect walks were conducted to observe flood-affected areas, drought-stricken grazing lands, soil degradation, and encroachment patterns. Secondary data were obtained from government reports, district profiles, climate policy documents, village land use plans, and academic publications. These documents provided historical and contextual information.

Measurement of variable was done through indicators such as frequency of droughts, rainfall variability, flood occurrence and temperature changes. Respondents rated severity on a 5-point Likert scale. The mediating variables including resource scarcity, pastoral mobility and land use overlap. This measured through frequency and severity scales. Moderating variables include institutional support, adaptation strategies, and socio-economic characteristics, measured through categorical and Likert-scale items. Dependent variable; land use patterns, measured through changes in cropping systems, farmland expansion, livestock mobility, and use of forest or marginal lands.

Ensuring the validity and reliability; content validity ensured through expert review by climate and land use specialists, construct validity

achieved by aligning items with established climate-livelihood frameworks, while face validity confirmed during pilot testing. A pilot study involving 40 respondents (10% of the sample) was conducted in a non-study village to ensure the reliability. Cronbach's alpha results show climate stressors: 0.82, land use practices: 0.79 and adaptation strategies: 0.84. All exceeded the acceptable threshold of 0.70. The trustworthiness of qualitative Data was maintained through credibility which achieved through triangulation and member checking, dependability ensured by maintaining detailed field notes and an audit trail, conformability enhanced through verbatim transcription and peer debriefing, while transferability supported by thick descriptions of the study context.

In data analysis, quantitative data were coded and analyzed using SPSS Version 20. Descriptive statistics such as frequencies, percentages, means, were used to summarize climate stressors, land use changes, and adaptation strategies. Qualitative data were analyzed using Braun and Clarke's (2006) reflexive thematic analysis, involving familiarization, coding, theme development, theme review, theme definition, and report writing. Themes were aligned with the study objectives.

RESULTS AND DISCUSSION

This section presents the findings of the study based on quantitative data from 391 household heads and qualitative insights from 26 key informants and eight focus group discussions. The results are organized according to the study objectives and supported by descriptive statistics and thematic analysis. A total of 391 questionnaires were administered to household heads across the four study villages. Of these, 366 questionnaires were fully completed and valid for analysis, yielding a response rate of 93.6%. Twenty-five questionnaires were excluded due to incomplete responses or inconsistencies identified during data cleaning.

Respondents included both farmers (n =193) and pastoralists (n = 173). Ages ranged from 30 to 80 years, with the majority (62%) aged between 35 and 60 years. Males constituted 79% of respondents, reflecting the cultural norm that household heads are predominantly men. Most respondents had primary-level education, and farming or livestock keeping was their main livelihood activity. These demographic characteristics provide context for interpreting land use decisions and climate change perceptions. Respondents were asked to identify the major environmental challenges affecting their land use practices. Four key

stressors emerged including drought, flooding, soil acidity, and erratic rainfall.

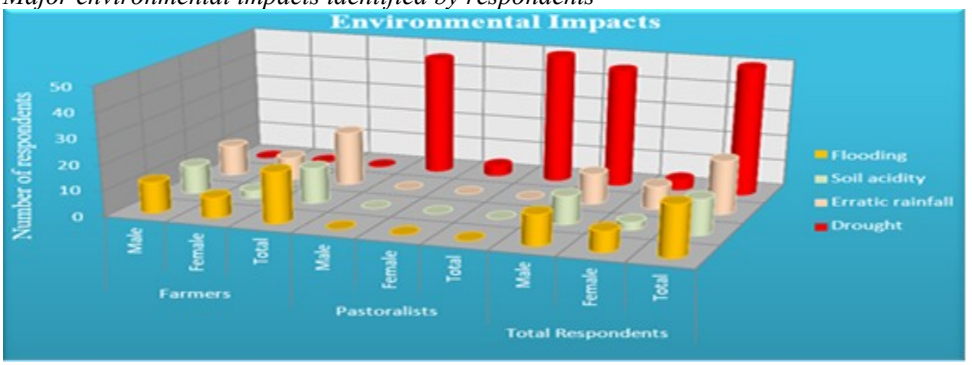
Table 1
Environmental Stressors Reported by Respondents

Environmental Challenge	Pastoralists (n=173)	Farmers (n=193)	Total (n=366)	Percentage (%)
Drought	165	28	193	52.7%
Flooding	5	142	147	40.2%
Soil Acidity	0	15	15	4.1%
Erratic Rainfall	3	8	11	3.0%

Source: Field Data (2024)

Drought was the most frequently reported stressor, cited by 52.7% of respondents. It was especially severe among pastoralists, with 95.4% identifying it as their primary challenge. Respondents explained that prolonged dry spells had depleted water sources and pasture, forcing livestock to migrate long distances. Flooding was the second most reported challenge, affecting 73.6% of farmers. Farmers noted that heavy rainfall events had become more unpredictable, damaging crops, delaying planting, and causing soil erosion. Soil acidity and erratic rainfall were less frequently reported but still contributed to reduced agricultural productivity and uncertainty in land preparation. During field observations, several low-lying areas in Hembeti and Doma villages were found submerged following intense rainfall. Farmers reported that such flooding events had become more frequent in recent years, destroying crops and forcing temporary relocation. The study examined how climate variability has altered land use patterns among farmers and pastoralists.

Figure 3
Major environmental impacts identified by respondents



Source: Field Data (2024)

Farmers reported several adaptive changes in response to climate stress including shifting to drought-tolerant and short-cycle crops, expanding farmland into previously uncultivated areas, increasing reliance on groundwater and small-scale irrigation, planting trees to restore degraded land, and adjusting planting and harvesting calendars. These changes were driven by unpredictable rainfall, declining soil fertility, and increased flooding. Pastoralists reported significant disruptions to traditional grazing patterns. Table 2 summarizes key indicators.

Table 2
Climate-related impacts on pastoralist mobility

Indicator	Respondents (n=173)	Percentage (%)
Pasture scarcity due to drought	171	98.8%
Long-distance migration (≥ 40 km)	168	97.1%
Live tock collapse/death due to hunger	168	97.1%
Slaughtering dying animals for survival	112	64.7%

Source: Field Data (2024)

Pastoralists explained that formerly grass-dominated rangelands had transformed into shrub lands due to rising temperatures. This ecological shift reduced forage availability, forcing livestock keepers to migrate up to 40 km in search of pasture and water. A key informant stated:

> *"Pasture has dried out due to high temperatures. The area has changed from grasses to shrubs and woods, which livestock cannot eat. This has forced us to move far from our homes."* (Key Informant, November 2024)

One of the most significant findings of the study is the link between climate change, land use overlap, and rising conflict.

Table 3
Effects of Climate-Induced Land Use Conflicts

Impact on Human Security	Pastoralists (n=173)	Farmers (n=193)	Total (n=366)	Percentage (%)
Physical assault or injury	122	138	260	71.0%
Destruction of property	95	104	199	54.4%
Deaths reported	48	52	100	27.3%
Sexual violence	7	11	18	4.9%
Fear and displacement	135	146	281	76.8%

Source: Field Data (2024)

Respondents reported that conflicts often began when livestock entered crop fields during migration. Farmers guarding their fields confronted pastoralists, leading to violent clashes. A farmer explained:

> *"When livestock enter our farms andwe try to chase them out, the pastoralists resist. They fight back with weapons. Some farmers have been beaten, even killed."* (Key Informant, November 2024)

Respondents noted that village leaders often failed to intervene promptly, perpetrators were rarely held accountable, and existing land use plans were poorly enforced. These weaknesses contributed to a cycle of revenge, fear, and displacement. The results demonstrate that, climate change has introduced severe environmental stressors, particularly drought and flooding, farmers and pastoralists have significantly altered their land use practices in response to climate variability, pastoral mobility has increased, leading to encroachment into farming areas, land use conflicts have intensified, resulting in injuries, deaths, displacement, and destruction of property, and institutional mechanisms remain weak, limiting effective conflict resolution and climate adaptation.

This section also discusses the study's findings in relation to existing global, regional, and national literature. The discussion is organized around the major themes emerging from the results including environmental stressors and land use dynamics, shifts in agricultural and pastoral practices, and climate-induced land use conflicts and human security.

Environmental stressors and land use dynamics

The study found that drought and flooding are the most significant environmental stressors affecting land use patterns in Mvomero District. More than half of the respondents (52.7%) identified drought as the primary challenge, while 40.2% reported flooding as a major concern. These findings align with global assessments by the IPCC (2022), which indicate that climate change is intensifying the frequency and severity of extreme weather events, particularly in tropical regions.

Figure 4
Flooding caused by erratic rainfall at Hembeti Village, Mvomero District

Source: Field Data (2024)

At the regional level, similar patterns have been documented across East Africa. Nkiaka *et al*. (2020) and Gebremeskel *et al*. (2021) report that prolonged droughts and erratic rainfall have disrupted agricultural calendars and reduced pasture availability, forcing communities to modify land use practices. The situation in Mvomero mirrors these regional trends, demonstrating how climate variability directly affects land productivity and resource availability.

Nationally, the Tanzania Meteorological Authority (TMA, 2022) has reported increasing rainfall variability and rising temperatures across the country. These climatic shifts have contributed to soil degradation, water scarcity, and reduced agricultural output. The presence of soil acidity and erratic rainfall in Mvomero, though less frequently reported, is consistent with findings from other Tanzanian districts such as Kilosa and Kiteto, where climate-induced soil degradation has reduced agricultural viability (Kangalawe, 2020). Overall, the environmental stressors identified in this study reflect broader climate change patterns observed globally and nationally, reinforcing the need for localized adaptation strategies.

Shifts in agricultural and pastoral practices

Farmers in Mvomero have responded to climate variability by adopting several adaptation strategies, including shifting to drought-tolerant and

short-cycle crops, expanding farmland into new areas. Increasing reliance on groundwater and small-scale irrigation, planting trees to rehabilitate degraded land, and adjusting planting and harvesting calendars. These findings are consistent with global literature indicating that farmers increasingly adopt climate-smart agriculture to cope with unpredictable weather patterns (Thornton *et al*., 2021). Similar adaptation strategies have been documented in Kenya, Ethiopia, and Uganda, where farmers have modified cropping systems to reduce vulnerability to climate shocks (Teshome *et al*., 2022).

In Tanzania, studies by Kashaigili *et al*. (2021) and URT (2023) show that farmers are increasingly adopting drought-resistant crops and expanding cultivation into marginal lands due to declining soil fertility and rainfall variability. The findings from Mvomero therefore align with national adaptation trends, highlighting the growing importance of climate-smart agricultural practices. Pastoralists in Mvomero reported significant ecological changes in grazing lands, including the transformation of grasslands into shrublands due to rising temperatures. This has resulted in increased long-distance migration example up to 40 km, higher livestock mortality, reduced milk production, and slaughtering of dying animals as a coping strategy. These findings are consistent with regional studies showing that climate change has disrupted traditional pastoral mobility patterns in East Africa (Herrero *et al*., 2020). In Kenya's Turkana and Ethiopia's Afar regions, pastoralists have been forced to migrate longer distances due to declining pasture and water availability (Mkutu, 2020; Gebremeskel *et al*., 2021).

Nationally, Msuya *et al*. (2020) reported similar patterns in semi-arid Tanzania, where recurrent droughts have reduced pasture quality and increased livestock mortality. The ecological shift from grasses to shrubs observed in Mvomero is also consistent with findings from Simanjiro and Kiteto, where rangeland degradation has intensified pastoral vulnerability (Maleko, 2015). Thus, the study confirms that climate change is reshaping pastoral livelihoods in Tanzania, with significant implications for mobility, livestock health, and household resilience.

Climate-induced land use conflicts and human security

One of the most critical findings of this study is the link between climate change, land use overlap, and rising conflict between farmers and pastoralists. More than 71% of respondents reported physical assault or

injury, while 76.8% reported fear and displacement due to conflict. These findings reflect a growing body of literature that identifies climate change as a catalyst for resource-based conflicts.

Globally, studies have shown that climate-induced resource scarcity increases the likelihood of violent conflict, particularly in regions where livelihoods depend heavily on natural resources (Detges, 2020). In the Sahel, for example, competition over water and grazing land has intensified clashes between farmers and herders (Nyong & Fiki, 2021). Regionally, East Africa has experienced similar tensions. In Kenya, Ethiopia, and Uganda, climate variability has exacerbated farmer–herder conflicts, often resulting in fatalities, displacement, and destruction of property (Mkutu, 2020; Teshome et al., 2022). In Tanzania, studies by Mwamfupe (2015) and Rweyemamu (2018) highlight that climate-induced migration and land scarcity are major drivers of farmer–pastoralist conflicts. The findings from Mvomero align with these national trends, demonstrating that climate change intensifies competition over land and water, leading to violent confrontations.

The study also found that weak institutional frameworks such as poor enforcement of Village Land Use Plans (VLUPs), inadequate conflict resolution mechanisms, and limited accountability exacerbate tensions. This is consistent with national reports indicating that land governance challenges undermine efforts to manage resource-based conflicts (MLHHSD, 2021). Thus, climate change does not act alone; it interacts with institutional weaknesses to produce conflict outcomes. Overall, the study demonstrates that climate change is a major driver of environmental stress in Mvomero, famers and pastoralists are adapting, but their strategies often lead to land use overlap, resource scarcity and mobility pressures intensify competition over land, weak institutions fail to mediate disputes effectively, and the result is heightened conflict, insecurity, and livelihood vulnerability. These findings reinforce global and national evidence that climate change is not only an environmental issue but also a socio-economic and security challenge.

CONCLUSION

This study examined how climate change affects land use patterns among farmers and pastoralists in Mvomero District, Tanzania. The findings demonstrate that climate variability particularly prolonged droughts, erratic rainfall, and seasonal flooding has significantly reshaped

agricultural and pastoral systems. These environmental stressors have reduced water availability, degraded soils, and diminished pasture quality, forcing both farmers and pastoralists to modify their land use practices. Farmers have responded by shifting to drought-tolerant crops, expanding farmland into new areas, adopting groundwater irrigation, and adjusting planting calendars. Pastoralists, on the other hand, have experienced severe pasture scarcity, leading to long-distance livestock migration, increased livestock mortality, and reliance on emergency coping strategies. These adaptations, while necessary for survival, have intensified land use overlap and competition for scarce resources. The study further reveals that climate-induced resource scarcity has escalated farmer-pastoralist conflicts, resulting in injuries, deaths, displacement, and destruction of property. Weak institutional mechanisms-including poor enforcement of Village Land Use Plans, limited conflict resolution capacity, and inadequate accountability-have exacerbated tensions and undermined community resilience. Overall, the study concludes that climate change is not only an environmental challenge but also a driver of socio-economic vulnerability and human insecurity in Mvomero District. Addressing these challenges requires integrated, multi-level interventions that strengthen adaptation capacity, improve land governance, and promote peaceful coexistence between farmers and pastoralists.

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