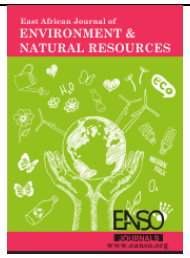

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Original Article

Effectiveness of Indigenous Techniques in Response to Climatic Stresses in Northern Tanzania: Insights from Maasai Communities in the Monduli District

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Keywords: *Indigenous Knowledge, Climatic stresses, Maasai agro-pastoralists, Monduli District, Adaptation Strategies, Northern Tanzania.*

ABSTRACT

Agro-pastoral communities are recognized as masters of innovative traditional adaptation strategies in dry lands. This study examines the effectiveness of indigenous knowledge in responding to climatic stresses in the Monduli district, Northern Tanzania. A mixed-method research approach was adopted, combining qualitative and quantitative data collection techniques. Primary data were collected through 315 household surveys, 12 focus group discussions, 25 key informant interviews, and field observations. Secondary data were sourced from records maintained by government institutions. Results were analyzed and presented using thematic content analysis and descriptive statistics. Most respondents (74.9%) indicated that birth control is an effective adaptation strategy for the Maasai agro-pastoralist communities in semi-arid areas. The main indigenous techniques were traditional birth control, acacia seed ponds in dry spells, traditionally constructed water wells and seasonal migration. Caution ought to be taken when generalizing and incorporating context-specific IK into local and national adaptation planning to ensure effective adaptation strategies.

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INTRODUCTION

Globally, Indigenous knowledge systems have developed over centuries, reflecting the intricate relationships between local communities and their natural environments. Indigenous knowledge system is a foundation for decision-making among indigenous and local populations in Africa and other disaster-prone regions (Dejene and Yetebarek, 2022). These communities effectively leverage their understanding of livestock management, natural resources, and subsistence livelihoods to navigate the challenges of disasters. Local communities worldwide have utilised Indigenous weather forecasting knowledge to make crucial decisions that help them adapt to climatic stresses (Balehegn *et al*., 2019). Indigenous Knowledge Systems (IKS) provide seasonal weather forecasts and resolve impending climatic stresses in rural areas. Rural communities living in disaster-prone regions rely on Indigenous knowledge to manage their livestock, natural resources, farming activities, and subsistence livelihoods (Chang'a *et al*., 2010; Mahoo *et al.*, 2015; Dejene *et al*., 2022). Agro-pastoralist communities rely on weather and climatic conditions for their livelihoods and can understand, forecast, and anticipate changes in weather patterns and other climate factors (Balehegn *et al*., 2019; Dejene *et al*., 2022).

Agro-pastoralism is vital in providing food and income for many people in Sub-Saharan Africa. Globally, an estimated 120 million agro-pastoralists exist, with 41.7% residing in Sub-Saharan Africa alone (Mohamed, 2019; Tofu *et al*., 2023). Agro-pastoralism significantly benefits East African economies. In Kenya, the industry is expected to reach a total worth of €750 million, with an annual marketing value ranging from €50 million to €80 million (Tofu *et al*., 2023). Tanzania boasts 15.8 million sheep and 17.4 million cattle (FAO, 2005a). Approximately 16.7 million of these cattle, representing 98% of the national herd, are owned by pastoralists and agro-pastoralists. Among them, 14% are managed within the pastoral system, while around 80% are part of the agro-pastoral system (URT, 2006). Agro-pastoralists comprise 7% of Tanzania's 3.7 million households, while pastoralists represent 3% (Kipuri and Sørensen, 2008). These statistics correspond to approximately 370,000 households, or roughly 2.2 million individuals, engaged in pastoralism or agro-pastoralism. Although the livestock industry constitutes only 5.9% of the GDP, it is essential for the country's meat production, pastoralists' livelihoods, and overall well-being (Mwakaje, 2013).

Despite its significant contribution, the agriculture and livestock sectors are more vulnerable to climatic stresses. Agro-pastoralists are especially susceptible to climatic stresses due to their predominantly tropical location and various socioeconomic, demographic, and regulatory factors that limit their capacity to adapt (Morton, 2007). Rural livelihoods depend more on weather conditions, making them increasingly vulnerable to extreme events such as droughts and floods (Sewando *et al*. 2016). The African continent is greatly affected by climatic stresses due to its vulnerability to climate threats, high sensitivity, and limited capacity for adaptation (Pauline, 2018; Mekonnen *et al.*, 2021). The global climate's impact on food supply will raise food costs, increase hunger risks for people in African countries, and hinder efforts to eradicate child undernutrition and malnutrition in all its forms (IPCC, 2022). Most

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experts agree that by the end of the century, temperatures across much of Africa will likely rise by over 2 ℃ based on medium emissions scenarios (Orlove, 2019). Extreme weather events such as tropical cyclones, heavy rainfall, and an increased likelihood of drought are becoming more frequent (Kangalawe, 2017; Pauline *et al.*, 2017). Approximately 85% of Africa's impoverished population resides in rural areas, primarily depending on farming and livestock for their livelihoods (IPCC, 2022). Climatic stresses are anticipated to significantly threaten food security across the continent, especially given the low capacity for adaptation in response to increasing human-induced pressures (Adams, 2020; Mahmood *et al*., 2019; IPCC, 2022). In Tanzania, climatic stresses have profoundly impacted agriculture and livestock, leading to loss of livelihoods, decreased production, and food insecurity among agro-pastoral communities (Liwenga *et al*., 2013; Ndesanjo *et al*., 2021). The increasing frequency and severity of droughts have resulted in higher livestock mortality rates and decreased crop yields, posing significant threats to agro-pastoralists who are heavily dependent on these resources (Galvin *et al*., 2001). Consequently, there have been substantial disruptions in the livestock and agricultural sectors, manifesting as crop damage and diminished productivity.

The Maasai agro-pastoralist communities rely entirely on their surrounding environment for their survival. They pass Indigenous knowledge through apprenticeship programs that educate young men and women about their community's systems (Ole Saitabau, 2014). Children grow up in traditional Maasai settings, engaging with the natural environment until adulthood. For rural Maasai agro-pastoralist communities, the need for adaptive strategies is becoming increasingly urgent to enhance their resilience and sustainability amid distinct environmental pressures. Climatic stresses present significant global challenges, yet adaptation strategies must often be customized to the unique contexts of each community. Various communities respond to these climatic stresses differently, influenced by time, social status, economic conditions, environmental factors, and geographical context (Niang *et al*., 2014). Enhancing Indigenous practices aimed at mitigating climatic stresses through traditional livestock and farming methods seeks to strengthen the resilience of Maasai agro-pastoralist communities in the face of diverse climatic challenges. In climate-sensitive regions, these communities have effectively utilized their indigenous knowledge systems (IKS) to adapt to changing climatic conditions (Ole Saitabau, 2014). These systems integrate indigenous techniques, including birth control methods, using acacia pod seeds, drilling river bends, utilising traditional water holes, and managing rangeland areas. Empirical evidence shows that rural communities have employed indigenous knowledge systems (IKS) for climate adaptation; however, concrete successes are still limited. Much of the existing literature focuses on the application of indigenous knowledge for seasonal forecasting among smallholder farmers and its role in forest conservation, as seen in studies by Chang'a *et al.* (2010), Mahoo *et al*. (2015), and Sanga & Haule (2022). Despite the growing literature on indigenous adaptation to climatic stresses, there is a significant gap in understanding the effective strategies recognized by Maasai communities. Additionally, research on how they perceive and interpret these techniques over time and space is limited. There is a gap in understanding how indigenous knowledge techniques used by Maasai agro-pastoralists effectively address climatic stress in the Monduli district of Northern Tanzania.

The primary objective of this study is to evaluate the efficacy of indigenous Maasai techniques in addressing climatic stresses. This research is particularly pertinent in the Monduli district, where such techniques remain inadequately documented in the existing literature. Agro-pastoral communities are recognized as experts in traditional adaptation strategies for drylands. They skillfully utilize environmental variability to maximize animal

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productivity during both times of abundance and scarcity. Additionally, they carefully manage rangelands during prolonged droughts (Lyimo & Kangalawe, 2010; Msangi *et al*., 2014). Specifically, this study explores the following questions: *How effectively do Maasai agro-pastoralists use the indigenous techniques in adapting to climatic stressors in the region? What are the challenges hindering indigenous adaptation in the study area?* The paper is expected to contribute to the debate on indigenous knowledge as a climate resilience tool among rural communities in semi-arid regions. This study will ensure comprehensive documentation of indigenous techniques used by Maasai agro-pastoralists to adapt to climatic stresses. It will provide coordinated, reliable, and accurate information on Maasai indigenous knowledge (IKS) for future research. The information gathered from this study is expected to enhance the existing literature and offer valuable insights to various stakeholders, including policymakers, decision-makers, and NGOs, to strengthen traditional strategies for climate change adaptation.

THE CONCEPTUAL FRAMEWORK

This study adopted and operationalized the Sustainable Livelihood Framework (SLF), a vital tool for understanding socioeconomic issues related to community livelihoods, poverty, vulnerability, and adaptability (Chambers & Conway, 1992; Reed *et al*., 2013). The framework is built on various assets, foundational pillars for long-term resilience and disaster adaptation (DFID, 2001). The presence or absence of these capitals significantly influences vulnerable individuals' capacity to cope with shocks and pressures, both from climate change and non-climate factors (Scoones, 2009). The framework consists of four primary components: the vulnerability context (major factors and stresses), agro-pastoralist assets (livelihood assets/capitals), livelihood outcomes, and policies and institutions (Fig. 1). Supportive policies and active local institutions are essential for enabling sustainable adaptation. In each community, the assets owned by households determine their income generation potential and ability to maintain their way of life (McLeod, 2001). Building resilience and enhancing adaptive capacity necessitates collaboration among agro-pastoralists, government entities, and community organizations. Livelihood outcomes hinge on the adaptation strategies developed in response to the vulnerabilities faced by agro-pastoralists due to climate-related stresses. Furthermore, all four components are interconnected within vulnerability contexts shaped by significant climatic shocks and stresses. This study examines the cultural contexts that influence the primary livelihood strategies of agro-pastoralist communities.

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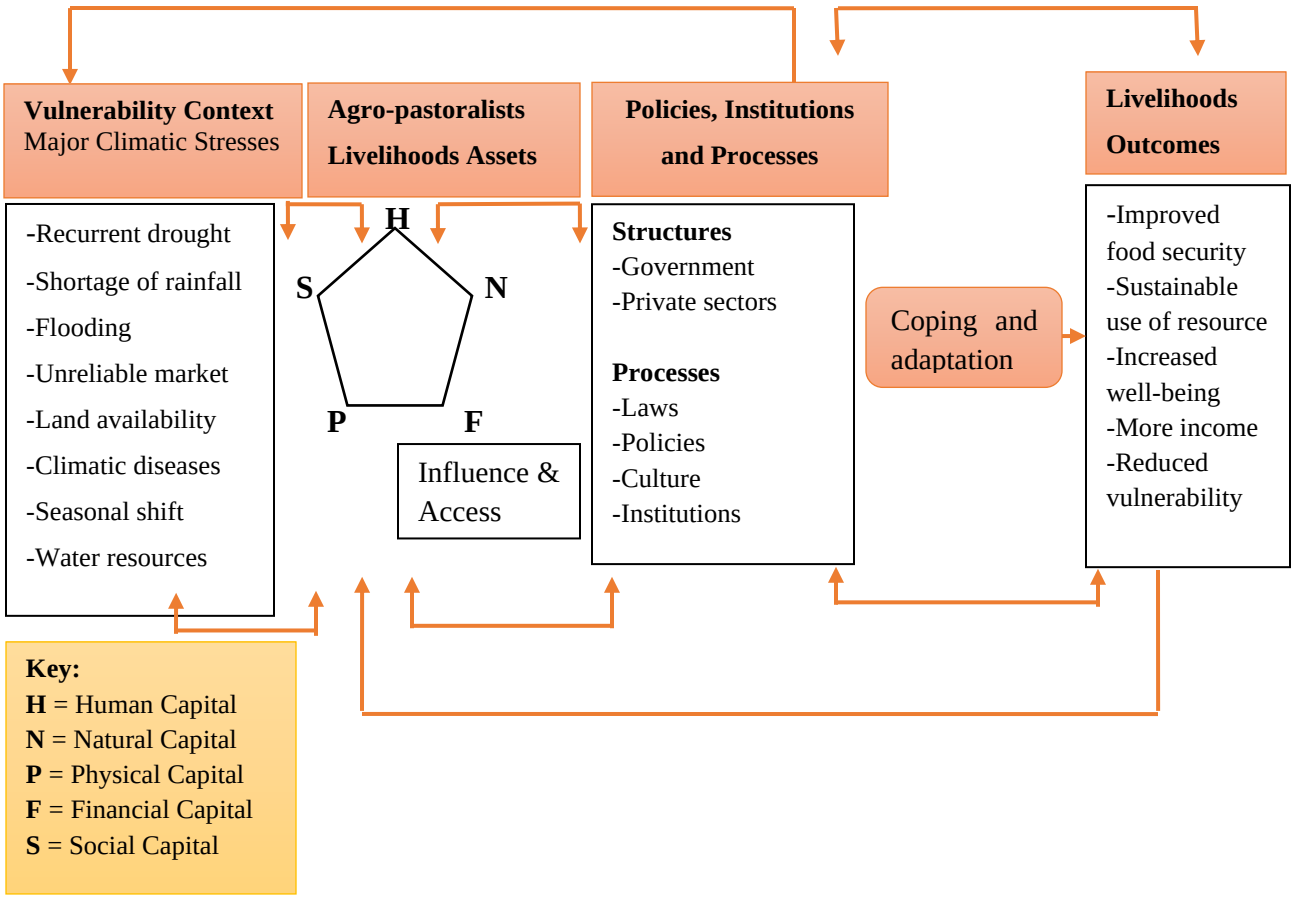
Figure 1: Sustainable Livelihood Framework



Source: *Adopted and Modified from Mafongoya et al. (2018).*

MATERIALS AND METHODS

Location of the Study Area

The study was conducted in the Monduli District in the Arusha Region of Northern Tanzania. (Figure 2). Geographically, the district is located between latitudes $3^0$20' 00" to 4^0 30' 00'' South of the Equator and Longitudes 36^0 27 00'' to 36^0 30 00'' East of the Greenwich Meridian (Kaswamila, 2009; Kimaro *et al.*, 2018). It borders the Longido district to the North, the Arusha Rural district to the East, and the Ngorongoro and Karatu districts to the West. To the South, it borders Simanjiro and Babati in the Manyara Region. It covers 6,419 sq. km, of which 6,290.62 sq. km (98%) is land and 128.38 sq. km (2%) is protected by water. The potential grazing land covers 3,988.855 sq. km; arable land covers 1,055.475 sq. km; and forestry covers 374.965 sq. km (URT, 2012). The study area was chosen because the Monduli District, located in Northern Tanzania, is home to Maasai agro-pastoralist communities. These communities are among the few in Tanzania that maintain traditional lifestyles and possess valuable indigenous knowledge systems for coping with climatic stresses (Onditi, 2016). Furthermore, the district was selected for the study because approximately 80% of its population comprises Maasai agro-pastoralists who rely on livestock and crop farming for their livelihoods, rendering them highly vulnerable (Kimaro *et al.*, 2018). Moreover, since 2009, the district has experienced livestock deaths and food shortages due, among other factors, to prolonged dry seasons and increased severe

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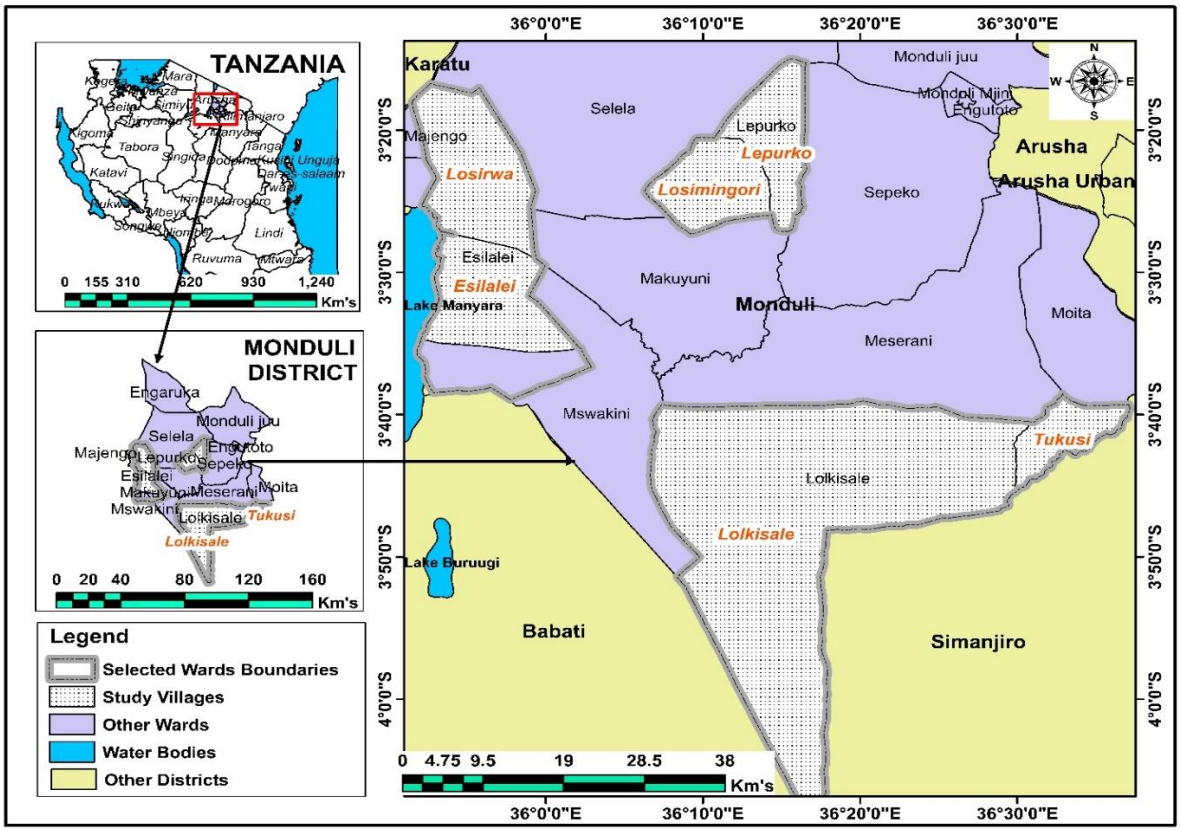
droughts that reduce the availability of pastures and water for livestock, making pastoralists vulnerable to food insecurity (URT, 2012). The vulnerability of climate change and variability to livestock has decreased the quality and quantity of animals, leading to food shortages and poverty among the agro-pastoralist households in the district (URT, 2012; Kimaro *et al*., 2018)

The study involved six villages in the Monduli district (Figure 2). It employed a mixed-method approach to enhance the understanding of key variables, promote inclusiveness, and provide triangulation and complementary research findings (Creswell, 2013; Ahmadi *et al.*, 2022). Simple random sampling was conducted to select heads of households from the registered list in each study village, with assistance from village leaders. A purposive sampling method was used to choose Maasai elders with at least 40 years of village experience and considerable Indigenous knowledge of dealing with climate stresses. Twelve Focus Group Discussions (FGDs) were held in six villages, each hosting one for men and one for women. This gender separation aligns with the cultural norm that encourages Maasai women to remain silent in the presence of men. The study involved key informants such as Maasai traditional leaders (*Ilaigwanack*), Chief Laiboni (Diviner), traditional weather seers, Maasai elders, livestock and agriculture officers, and village government officers.

Figure 2: Map of Monduli District Showing the Study Area



Source: *GIS Lab, University of Dar es Salaam (2024)*

The sampling frame for this study included 1,472 households from six villages. Household heads were chosen as the most suitable candidates to provide accurate responses because they were well-informed about the extreme climatic events relevant to the study. Based on this sampling frame, 315 respondents were selected using a formula that

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Owuor & Mwiturubani (2021) adopted at a 95% confidence level with P = 0.05, as illustrated below.

$$\mathbf{n = \frac{N}{1 + N(e)^2} = \frac{1472}{1 + 1472(0.05)^2}\ n = 315}$$

Where n is the sample size, N represents the total population size, and e is the precision (sampling error) = 0.05%.

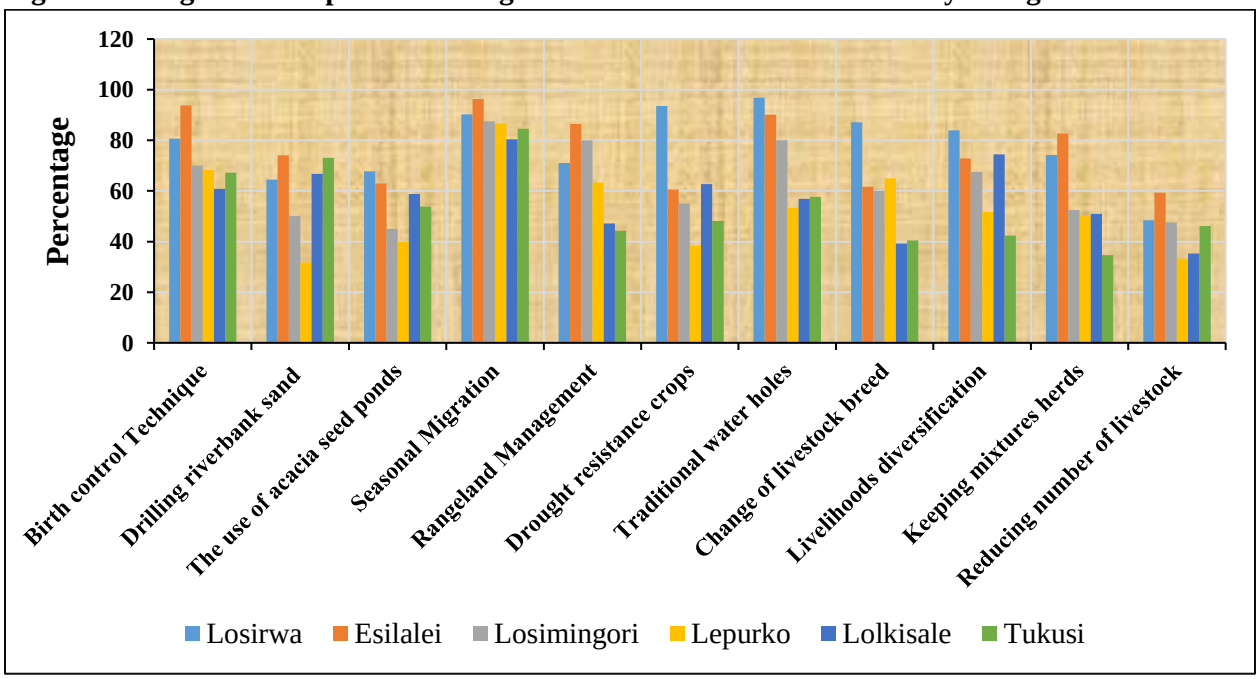
Qualitative data were gathered through Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), and field observations using audio recorders and notebooks. Subsequently, these notes were coded, transcribed, and translated from Maasai to English. This was followed by a thematic analysis that presented findings as a narrative summary supported by relevant quotes. Quantitative data were collected through a questionnaire survey, which was edited to facilitate coding. A descriptive method was employed to summarize this data, generating frequencies, and graphs to enhance clarity and effectively communicate the research findings.

RESULTS AND DISCUSSION

The Effectiveness of Maasai Indigenous Techniques Used in Adapting to Climatic Stresses

Agro-pastoral communities are recognized as *"masters of innovative traditional adaptation strategies in dry lands."* They leverage variability to optimize animal productivity in plentiful and scarce periods and methodically oversee rangelands during prolonged droughts (Lyimo & Kangalawe, 2010; Msangi *et al*., 2014). The study's findings revealed that Maasai agro-pastoralists in the study area employ several adaptation mechanisms to deal with different climatic stresses, such as droughts, unpredictable rainfall, and livestock deaths (Figure 3). Overall, the main Indigenous techniques and strategies used by the Maasai agro-pastoralist communities such as the traditional birth control technique, drilling riverbank sand to access water, the use of acacia seed ponds in dry spells, seasonal migration, the use of a traditional constructed water well, and traditional rangeland management practice.

Figure 3: Indigenous Adaptation Strategies to Climatic Stresses in the Study Villages



Source: *Field Survey, (2024)*

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Traditional Birth Control Technique (TBCT)

Findings obtained from household surveys showed that birth control is an effective Indigenous adaptation strategy that enables the Maasai agro-pastoralist communities to plan the timing of livestock reproduction, mainly sheep and goats. This was reported by 74.9% of respondents from the surveyed villages (Figure 3). Results indicated that Maasai agro-pastoralists use two birth control methods for small ruminant animals (Sheep and goats). The first method involves dressing male goats or sheep (rams) in traditional pockets made of plastic materials. These pockets cover the loins of the animals, preventing them from mating with female goats or sheep (Plate 1). The second method involves separating female and male livestock to prevent mating during night and grazing hours. The findings align with Joseph & Kaswamila (2017), who argue that managing livestock reproduction, especially for goats, is used to cope with water scarcity caused by prolonged droughts. Mfinanga *et al.* (2023) argued that birth control enables pastoralists to efficiently plan animal reproduction, especially in areas with limited water and pasture resources. The research revealed that agro-pastoralists have employed age-old methods to reduce the frequency of births during extreme drought. Following the Maasai traditional calendar, female sheep and goats are allowed to breed with males from early July, which aligns with August in their calendar. This leads to births taking place more than three months later. However, the practice of these techniques varied among the study villages. Esilalei had the highest application rate at 93.8%, followed by Losirwa (80.6%), Losimingori (70.0%), Lepurko (68.3%), Tukusi (67.3%), and Lolkisale, with the lowest at 60.8%. The findings from the study were supported by participants in the focus group discussion in Losirwa village, who recounted that:

> *"In our village, we use indigenous knowledge for planning purposes, especially when letting goats and sheep give birth. Nowadays, we will enable sheep to meet a ram from 10 July every year, which will take about 150 days to give birth. Therefore, from the 7th to the 8th of December, during the short (vuli) rains, those sheep start to give birth. This helped us to save our laps from dying during the dry seasons"* (An agro-pastoralist respondent aged 35 years in Losirwa Village, 20th February 2024).

> *"In lowland areas, birth control techniques have been frequently used to control the birth of livestock, mainly sheep. This is because during droughts from September to November, the quality of newborn lambs decreases. The sheep cannot produce enough milk for the lambs, causing them to remain weak and eventually die. As a result, the quantity of sheep decreases because no new lambs means no increase in the number of sheep, and vice versa. However, this method was introduced not to reduce the number of livestock but to protect their quality and the optimal time for them to give birth, thereby reducing the rate of livestock death during severe droughts"* (An agro-pastoralist respondent elder aged 60 years in Losimingori village, 15th March 2024).

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Plate 1: Rams with a Plastic Pocket Restricting from Mating with Female Sheep in the Study Area

Source: *Field Survey, (2024)*

Drilling Riverbank Sand

Results revealed that 60.6% of the respondents from all villages stated that drilling water from the sand is a crucial adaptation method agro-pastoralists utilize to access less salty water during prolonged droughts (Figure 3). Maasai women primarily use this technique to access water for domestic use and weak animals during severe droughts. They retrieve the water from the sand and then bury it to conserve it from evaporation and destruction by wild animals (Plate 1). Moreover, donkeys are crucial in the Maasai community as they play a significant role. They carry maize meal and water from distant areas and are used during seasonal migration to transport various loads. Donkeys are commonly used for seasonal household relocations and to transport domestic water during the dry season every few days. Likewise, Marshall & Wessbrod (2009) state that donkeys are essential for moving supplies from rural retail centres, such as maize meal, sugar, and tea. These findings were supported during a key informant interview, who narrated that:

> *"During the dry season, typically from August to October, the water in the locally constructed dams becomes too salty for domestic use. As a result, we drill into the riverbank sand to obtain water that is not entirely fresh but has a lower salt content than water from traditional wells. After fetching this water, we bury the sand to protect it from livestock damage, helping us cope with the frequent and prolonged droughts in our area"* (An agro-pastoralist woman aged 38 years, in Losirwa Village, 24th February 2024).

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Plate 2: **The Drilling of Water from the Sand During the Drought Season in the Study Area**

Source: *Field Survey (2024).*

The Use of Acacia Seed Ponds in Dry Spells

Household surveys indicated that 54.6% of respondents use acacia seed pods to feed their livestock, particularly goats and sheep, during extended periods of drought in their local areas (Figure 3). The survey highlighted that seed pods (locally known as *'Isogororom)* from the acacia tree, locally referred to as "Oltepesi," are recognized as an effective indigenous adaptation strategy utilized by Maasai agro-pastoralists to address climate-related stresses (Plate 2). The findings of this study support the conclusions of Mesfin *et al.* (2020), who argued that the leaves, twigs, and seed pods of acacia trees play a crucial role as a feed source for livestock in Ethiopia, particularly during extended dry periods when grass is scarce or unavailable. Also, Acacia is a native tree known for its high nitrogen content. FGD also showed that the availability of acacia seed pods varies among ecological zones. They are more available in lowland areas, especially during the low rainy season, compared to the high rainy season, when they are scarce. An analysis based on the villages shows that this Indigenous adaptation strategy varies among the study villages: Losirwa village had the highest percentage, 67.7%, followed by Esilalei (63.0%), Lolkisale (58.8%), Tukusi (53.8%), Losimingori (45.0%), and Lepurko (40.0%). During focus group discussion with the Maasai elders in Esilalei and Tukusi villages, respondents supported these findings and argued that:

> *"Acacia trees play a crucial role during dry spells by producing seed pods that are particularly valuable during prolonged droughts in our area. The presence of acacia trees near our homes determines the availability of these seed pods, making it easier for calves and lambs to access them without traveling long distances. These seedpods contribute to the health and resilience of livestock, especially goats and sheep, in the face of prolonged droughts"* (An agro-pastoralist respondent aged 40 years in Esilalei village, 20th February 2024).
>
> *"..... Also, annual rainfall primarily determines the existence of acacia seed pools in*

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semi-arid environments. In years with low rainfall, the acacia trees produce many white flowers, indicating many seed pods during the dry period. For instance, in 2023, when the rainfall was low and ended early in May, the number of acacia seed pools was higher compared to 2024, when there was significant rainfall in semi-arid areas". (An agro-pastoralist respondent elder, aged 55 years, in Tukusi village, 18th April 2024).

Plate 3: **An Agro-pastoralist Shaking an Acacia Tree with a Long Stick to Drop Seed Ponds**

Source: *Field Survey (2024)*

Seasonal Migration

The study found that Maasai agro-pastoralists use indigenous knowledge to adapt to climate disasters. A household survey indicated that about 88.2% of the respondents noted using seasonal migration as their primary and effective adaptation strategy against prolonged drought (Figure 3). The findings showed that the Maasai communities used knowledgeable people and traditional experts, particularly diviners (locally known as *Iloibonok*-plural), to guide seasonal migration zones and predict favourable migration areas for the health of livestock and human beings. Moreover, FGD reported that seasonal migration mainly occurs during prolonged drought, typically from July to August (Plate 3). Based on rainfall patterns from August to September, they move from one district to another or to a different region in search of pasture and water and to avoid disease outbreaks. Similarly, Mung'ong'o *et al.* (2019) argued that agro-pastoralists migrate depending on seasonal rainfall, usually during the short (*vuli*) rains between September and December. However, migration enables the vegetation to regenerate and reduce the overuse of that land for the same purpose. Most agro-pastoralist areas are semi-arid lands that dry soon after the cessation of long rains (Masika) and turn into dry land that does not support livestock activities. The temporary migration of livestock herders in search of pastures and water is prevalent among agro-pastoralist groups (OXFAM, 2008; Liwenga, 2016). The mobile herding of animals is crucial to their way of life. These agrarian communities often relocate to adapt to the unpredictable nature of rainfall (Oba & Lusigi, 1987). A respondent supported these findings during a key informant interview in Losimingori village, who narrated that:

"Migration helps regenerate new vegetation covers, and it controls erosion. Furthermore,

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seasonal migration helps to save our weak animals, especially cattle and sheep, during prolonged drought. The seasonal rainfall forces us to search for a place where rainfall has followed, where our livestock can get pasture and water, enabling them to wait for the long rains expected to take place in March" (An agro-pastoralist 86-year-old man in Losimingori Village, in the year 2024).

Plate 4. The Seasonal Migration in the Study Area During Severe Drought

Source: *Field Survey (2024)*

Use of Traditional Constructed Water Wells

The study revealed that Maasai agro-pastoralists leverage their indigenous knowledge to construct traditional water holes, enabling them to adapt to climatic challenges. Approximately 71.7% of respondents indicated that utilizing these traditional water holes is an effective strategy for coping with severe droughts across all the villages examined (Figure 3). The water well or hole, known as *"Olchoro,"* varies in size and depth but has a consistent shape constructed along the river bed purposely for livestock and domestic use. It consists of two main parts: a locally built water hole (*Olchoro*) and a long trough known as an "*Embeuti*," from which livestock can drink. This strategy varied among the study villages. Losirwa village had the highest percentage at 96.8%, followed by Esilalei at 90.1%, Losimingori at 80%, Tukusi at 57.7%, Lolkisale at 56.9%, and Lepurko at 53.3%. This study's findings align with those of Mwangi & Rutten (2012), who argued that temporary traditional dug wells are basic hand-excavated pits created along riverbeds. They are used to retrieve water for livestock and human consumption.

Moreover, the water supply schedule allows for the proper use of traditional water wells by taking water one day and skipping the next. This helps livestock, such as sheep, goats, and cattle, cope with drought. It also allows another user from the same clan to utilize the well. The water supply technique for sheep will enable them to go up to 3 days without water, while goats can go up to five days without water. Likewise, Mung'ong'o *et al.* (2019) argued that constructing these wells ensures a continuous water supply for human and livestock use, addressing water availability issues, especially during the dry season. Key informants and

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household surveys reported that traditional water holes are owned by specific clans and are utilized by the community. This implies that each water well belongs to a member of one of the five Maasai clans: Lazier, Mokesen, Mollel, Lukumay, and Iltariosero. The respondents during the focus group discussion supported these findings and added that:

> *"Traditionally constructed wells are critical during the drought season. In our community, we have a traditional water well called "Olchoro," which is owned by the clan. This makes it easier to manage and sustainably use the resource. Even during seasonal migration, a person from another Maasai region or district has the right to use a traditional well belonging to their clan, regardless of their origin"* (An agro-pastoralist respondent aged 56 years in Losirwa village, 21st February 2024).

Traditional Rangeland Management Practice

Results indicated that the Maasai agro-pastoralist communities employ a variety of land management systems that emphasize communal resource ownership. Approximately 66.3% of respondents concurred that traditional rangeland management practices are effective climate adaptation strategies (Figure 3). The community owns the rangelands or traditional forests rather than individuals or specific groups. Maundu *et al.* (2001) argued that Maasai communities utilize forests and trees to communicate with "God," who is revered as the bestower of rain and a protector, particularly during severe weather such as drought or epidemic diseases. The findings further indicated that traditional rangeland management (locally known as *Ilolilia/Ilokeri*) serves several purposes. These include providing grazing areas for calves during drought periods, preventing land degradation, protecting weaker animals during severe droughts, and conserving natural forests, which are home to ceremonial plants and traditional medicinal trees. Respondents supported these findings during Key informant interviews in Losimingori village, who narrated that:

> "*Our rangeland areas (Ilolia/Olokeri) are highly preserved for different purposes, including enabling calves to access the pasture nearby and to save them during prolonged drought and protecting ceremonial and medicinal plants found in Losimingori Mountain, which are very important in maintaining our traditional way of life. The community's elders and our chief, Oloiboni, are the primary custodians who restrict people from entering the forest without their permission. Also, at the same time, forest conservation in the mountains helps us to get rainfall early compared to other areas with no forest" (*An agro-pastoralist respondent aged 46 years in Loosimingori village, 18th March 2024)

Challenges to the Effectiveness of Indigenous Techniques in Response to Climatic Stressors

The key barriers confronting the effectiveness of indigenous response techniques to the impacts of climatic stressors are substantial. The study identified three primary factors that impede the effectiveness of indigenous techniques in addressing climatic stresses. These factors include land use changes, climatic extremes and variability, and financial constraints, which significantly challenge the efficacy and sustainability of indigenous methods in the study area. The study indicated that land-use alterations were significant determinants influencing the efficacy of indigenous strategies. Approximately 49.2% of the respondents from the surveyed villages indicated that land use change is a significant factor undermining the effectiveness of traditional techniques used to address climatic stresses. This concern was most pronounced in Lepurko, Esilalei, and Losimingori villages, where the percentages were 58.3%, 58.0%, and 52.5%, respectively. This was followed by Tukusi at 42.3%, Lolkisale at 39.2%, and Losirwa village, where only 32.3% of respondents expressed similar concerns (Figure 4). The expansion of conservation zones for tourism activities has marked land use changes, the rise of agricultural

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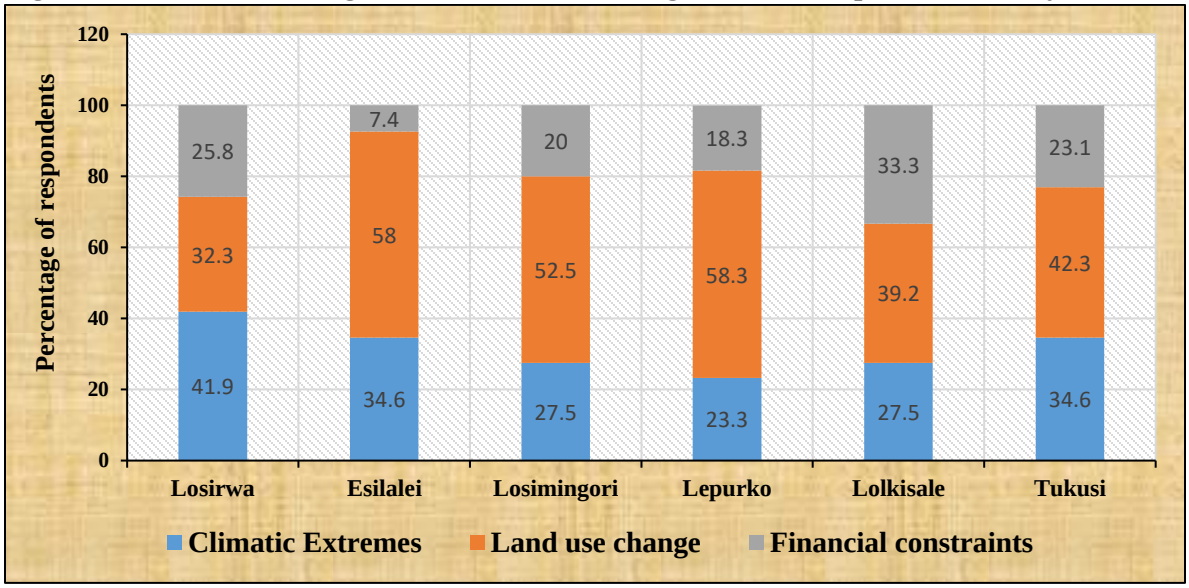
estates, and the privatization of land, all of which have adversely impacted traditional rangelands. This shift has significantly disrupted the communal management of livestock grazing territories that local communities rely on. The current study reveals that a grazing forest, historically preserved by the community for use during extended droughts in Losimingori village, has been reclassified as a government-regulated forest reserve, now known as the "Esmingor Forest Reserve". Our findings align with the argument put forth by Sulle and Nelson (2009), which posits that governments actively pursue policies aimed at fostering foreign investment in wildlife tourism. This pursuit has led to the critical issue of agro-pastoralists' displacement from their ancestral lands. The findings were corroborated by participants in a focus group discussion in Losimingori village, who emphasized that:

> *"The transformation of the community forest into a government conservation area has significantly increased the distance calves and sick animals must cover to reach the now-scarce grazing areas, much farther from established residential locations. Moreover, these changes have restricted the community's ability to access forests for traditional practices, such as ritual observances and rain-making ceremonies. These are vital components of Indigenous knowledge systems essential for weather forecasting"* (An agro-pastorlist respondent aged 70 years, in Losimingori village, 18th March, 2024).

Figure 4: Factors Hindering the Effectiveness of Indigenous Techniques in the Study Area



Source: *Field Survey, (2024)*

The results revealed that 31.1% of the interviewed respondents indicated that climate extremes and variability impact the effectiveness of indigenous techniques. Perspectives varied between villages, with Losirwa village reporting the highest percentage at 41.9%. This was followed by Esilalei and Tukusi villages, each at 34.6%, then Lolkisale at 27.6%, Losimingori at 27.5%, and finally Lepurko village, which had the lowest at 23.3% (Figure 4). Climatic extremes and variability have emerged as significant challenges that undermine the effectiveness of traditional strategies for mitigating climate-related stressors. Unpredictable rainfall patterns, delayed rainy seasons, early cessation of rains, and extended droughts have significantly reduced the efficacy of these

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conventional measures. Consequently, there have been noticeable impacts on seasonal migration patterns, traditional birth control practices, the diminished production of acacia seed ponds, the drying of traditionally constructed water wells, and crop failures. For instance, in Lolkisale village, water wells built on the riverbed were destroyed by floods during the heavy rainfall season in March and April 2024.

The study's findings indicate that 19.7% of respondents identified financial constraints as a significant factor limiting the effectiveness of indigenous measures in response to climatic stressors. Financial constraints present a significant challenge to this adaptation strategy, as the Boran breed can be costly and unaffordable for many. Traditionally, crossbreeding local livestock with breeds known for their heat and disease tolerance has been a common approach to overcoming agricultural challenges. The Boran breed, imported from Kenya, provides notable market advantages over local breeds due to its larger size and weight. This process involves selectively breeding local cattle to develop more resilient varieties with higher milk and meat productivity than their local counterparts. However, the data reveals significant variation in percentages across different villages. Lolkisale village exhibited the highest proportion, with 33.3%, followed by Losirwa village at 25.8%. Tukusi village accounted for 23.1%, while Losimingori village recorded a percentage of 20.0%. Lepurko village demonstrated an 18.3% share, starkly contrasting with Esilalei village, which represented the lowest percentage at just 7.4% (Figure 4).

However, apart from three key barriers, modernization, mainly through the spread of Western education and Christianity, has significantly hindered the use of indigenous knowledge and traditional ways of life in many regions, including the study area. This has weakened the sustainability and effectiveness of indigenous techniques in addressing climatic stresses. These findings align with Sanga & Haule's (2022) arguments, who observed that modernization, primarily driven by the influences of Christianity and Western civilization, has transformed African socioeconomic systems, often at the expense of traditional practices. This erosion of indigenous cultures has, in turn, led to a significant decline in the utilization of indigenous knowledge in forest conservation efforts. The study revealed that indigenous knowledge is at risk of being lost due to inadequate documentation and a lack of interest among the younger generation in utilizing and preserving it. This potential loss of information is worsened when the elders, the primary keepers and custodians of this knowledge, pass away. Furthermore, there is a significant generational gap between the younger generation and the elders responsible for maintaining this knowledge.

CONCLUSION AND RECOMMENDATIONS

The study evaluated the effectiveness of indigenous knowledge techniques in tackling climate-related stresses and challenges that hinder the sustainability of these adaptation strategies within Maasai communities in the Monduli district of Northern Tanzania. Indigenous knowledge is vital for addressing climate change and variability in semi-arid regions. It is a crucial resource for local adaptation planning, particularly in areas with limited access to scientific weather information. However, the effectiveness of indigenous methods varies by ecological zone. Using acacia seed ponds, constructing traditional wells, and employing birth control techniques are more effective for adapting to climatic stresses in lowland areas than in highland regions. The significance of indigenous knowledge has waned in contemporary society, mainly due to modernization. This decline is primarily fueled by the influences of Western education and Christianity, inadequate documentation of traditional practices, and disinterest among younger generations in preserving and applying this knowledge. Furthermore, the potential loss of

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invaluable information increases with the passing of elders, who serve as this wisdom's main keepers and custodians.

The study recommends integrating context-specific indigenous knowledge systems into local and national adaptation planning to ensure effective adaptation strategies. This will reduce vulnerability, strengthen the resilience of Maasai agro-pastoralist communities, and enhance their adaptive capacity in the face of unpredictable climatic stressors. There is a pressing need to document indigenous knowledge related to climate change adaptations, which would strengthen accuracy and resilience within Maasai agro-pastoralist communities. This can be achieved by promoting community participatory research that collects oral histories and insights from Maasai elders. Such an approach will help ensure that Indigenous practices are preserved even after the passing of the elders, who are the primary custodians of this knowledge.

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