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Local adaptation strategies against climate change among the oscillating agro-pastoral Maasai communities, Tanzania

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Abstract

This study assesses the pastoral Maasai adaptation to climate changes in Losinyai, Orjoro no.5 and Shambarai Sokoni Wards in Simanjiro District. Data were collected using household surveys, key informant interviews and documentary reviews. Data were coded and analysed using Statistical Package for Social Sciences (SPSS), where both descriptive and inferential statistical techniques were applied. The results indicate an annual fluctuation of both rainfall and temperature in the study area. The major drivers of these changes are deforestation and charcoal making, and overstocking, which impose high pressure on land resources in the study area, leading to loss of grazing land, drought, land-use conflicts, and water sources. Initiatives taken by Pastoral Maasai to cope with the situation include moving cattle to wetland areas, pasture restoration, buying hay, destocking and keeping resistant breeds. The measures suggested to improve the traditional strategies include opening the cattle grid, providing grass seeds and modern livestock keeping education. The study recommends the need to control keeping small herds of cattle, integrate land use plans, and advance the current community by-laws that will prevent encroachment of the cattle grid from enabling the movement of livestock to resource points during drought conditions. The results of this study are helpful to advance our policies and practices, which are beneficial to increasing the resilience of local communities to climate change.

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Introduction

Climate change is a global critical development challenge affecting many sectors earth-wide and is considered to be one of the most serious threats to sustainable development; it is expected to intensify existing problems and create new combinations of risks, particularly in Africa (Akinnagbe & Irohibe, 2015). Globally, native grasslands, forests, and wetlands are greatly affected by climatic variability. Many ecosystem services and biodiversity are destructed due to a shortage of rainfall and highly increased temperature (Metzger *et al.*, 2006).

In Africa, temperatures are reported to have increased from 1970 to 2004. Reports show an increase in temperatures in the African region by 1–2ºC by the end of 2025 (Mitchell, 2013). The temperature in Africa has increased by more than 0.5˚C during the last 50 to 100 years (Gan *et al.*, 2016; IPCC, 2014; Niang *et al.*, 2014). Furthermore, the maximum and minimum temperatures have shown positive trends during the last decades (Adhikari *et al.*, 2015; Mengistu *et al.*, 2014; Niang *et al.*, 2014). The increase in temperature is accompanied by a steady decline in precipitation in some parts of the African region (Lyon & DeWitt, 2012; Mekasha *et al.*, 2014), but the observed long-term precipitation trends are not significant (Mengistu *et al.*, 2014). Thus, the need for site-specific impacts studies is essential for designing future mitigation options.

Tanzania experiences varieties of climatic conditions ranging from humid coast to moist tropical forest in the highlands (Lekule, 2011). Climate change in Tanzania is taken with evidence of the receding ice on Mount Kilimanjaro and freshwater intrusion by saltwater in the shallow wells of the Bagamoyo district (Lekule, 2011). These are examples of climate change in Tanzania, such as the prolonged drought of 2008/2009. However, 100 years of disaster records in Tanzania show that more than 33% were related to drought, indicating climate variability. Climate change impacts are increasingly pronounced in semi-arid regions where most pastoralist and agro-pastoralists gather their livelihoods (Lekule, 2011; Nyembo *et al.*, 2022). As a result, climate change would affect many community members, from households and livestock keepers to plantation agriculture. Thus, there is a pressing need to address future resilience.

Climate changes can intensify the existing pressures on human security, including the pressure on food, health, and economic insecurity in most African countries (Pachauri *et al.*, 2014). Topographical location and socioeconomic attributes in East Africa make the regions among the most vulnerable to the current temperature variations attracting several studies with broader consequences (Nyembo *et al.*, 2022; Omambia *et al.*, 2017). A more pronounced evidence of climate change currently includes frequent droughts and an increase in drylands areas, affecting water and food availability for humans, livestock, and wildlife (Munishi *et al.*, 2015; Omambia *et al.*, 2017). For instance, the fast retreats of glaciers on Mount Kilimanjaro in Tanzania and Mount Kenya in Kenya and changes in the rainfall patterns in the East Africa region have been reported as evidence of climate change impacts. This phenomenon has the potential to impact livestock keepers in many dimensions.

Climate assessments reports named Tanzania among countries prone to extreme weather events, ranging from droughts to floods (Pachauri *et al.*, 2014). The temperature rise, for example, results in an elevation in evapotranspiration, changes in timing, consistency, the intensity of rains, duration and incidence of floods and droughts (Oguge *et al.*, 2011). The impacts of climate change could be noted in variations in surface water discharges, quality and groundwater table fluctuation (Mckenzie *et al.*, 2010). As a result, water managers have shifted their focus to developing groundwater systems for domestic uses and agricultural production (Singh & Kumar, 2014). Although the natural groundwater recharge solely depends on precipitation pattern (Shah, 2009); however, as observed in Tanzania, there are also variations in yields of boreholes due to increases in climate variabilities (Kashaigili, 2010).

Thus, there is a need to better understand the impacts and the local adaptation strategies for the livelihood of the Maasai communities. The pastoral land has experienced the destruction of a native forage; the death of native forage restricts livestock forage selection in a particular area because of the disappearance of the highly nutritious plant, which is grazed mainly by livestock (Roever *et al.*, 2015).

The large size of the rangelands has experienced a shift in plant species due to climate change that threatens the ability of desirable perennial plants to regenerate hence the total loss of favoured plant species (William, 2003). Simanjiro, over other districts, is pronounced for climate change events and land use changes (Kshatriya *et al.*, 2002).

There has been limited attention to the pastoralist traditional adaptation practices to climate change (Galvin *et al.*, 2004). Therefore, this paper aims to explore the pastoralists adaptation measures and/or mechanisms in addressing the impacts of climate change and investigate how traditional adaptation measures can be integrated into modern science.

The results of this paper are expected to increase the resilience of communities to climate change and increase community livelihood.

Materials and methods

The study area

This study was conducted in three wards of the Simanjiro district (Fig. 1). Simanjiro district is a semi-arid area characterized by a sparse population, divided into six administrative divisions with 17 wards and 39 registered villages. It has a land area of 20,591 km², of which 600 km² is fertile land, 12,682 km² is hunting blocks, and the rest are hilly areas (URT, 2012). Simanjiro district is a largely semi-arid zone with a bimodal rainfall regime, the annual rainfall in Simanjiro district sums to 650mm per annum, and the temperature varies between 18-30˚C (Salekwa *et al.*, 2014). The short rains are between November and December, whereas the long rains are from February to April. The dominant vegetation is wooded bushland and bush occupied by the Kisongo Maasai pastoralists. According to the 2012 census, the population was 178,693, and the population growth rate per annum was 2.37% per year (URT, 2012). Simanjiro mainly comprises open woodland, bushy forests, and grassland vegetation (Salekwa *et al.*, 2014). The Simanjiro district borders the Tarangire National part, making it an important area for wildlife dispersal with humans and wildlife interaction (Salekwa *et al.*, 2014). The dominant vegetation is wooded bushland and bush occupied by the Kisongo Maasai pastoralists, making pastoralism a vital livelihood activity in the area.

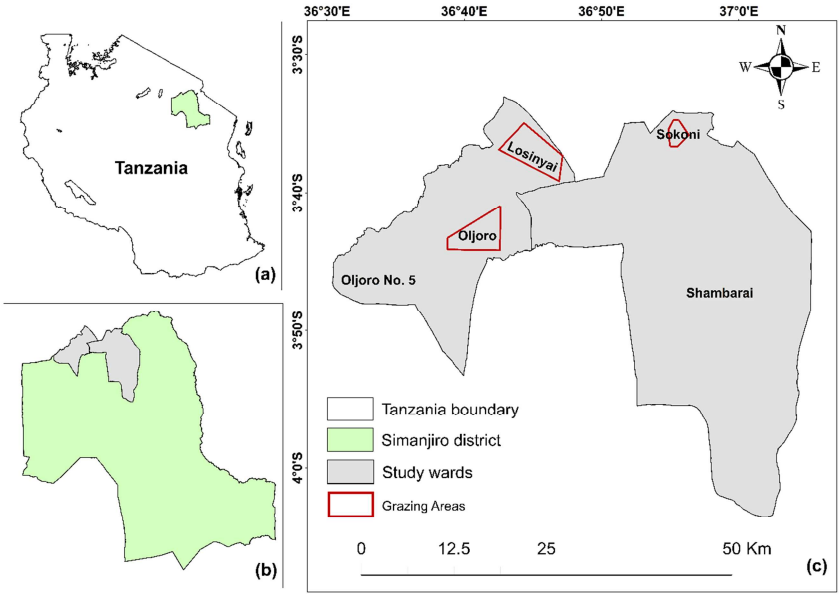

Fig. 1. The study area (Adopted from Seni *et al.*, 2022).

Data collection and analysis

Household Survey techniques

The study employed randomly administered open-ended and closed-ended questionnaires to get the required information from the households. The questionnaire covered socioeconomic and demographic information, forms and causes of climate change and impacts, and adaptation measures. Key informant interviews were also conducted in each wards, including chairpersons, Ward Executive Officers, and ward livestock field officers. The motive behind using this method was to capture the knowledge and experience of the appropriate government officials and community elders. The criteria were the representation of administrative wards, the intensity of climate and accessibility.

Sampling procedures

Systematic, random sampling and purposive sampling were used; this was aimed to avoid biases in sampling and information acquisition. Systematic random sampling was used to select households from village book registers by dividing the number of units in the sampling frame (N) by the number desired for the sample (n) to have a skip interval (k) which was picked to form up the sample size.

According to population data available, Losinyai village has 2986 residents, Shambarai Sokoni has 5875 residents, and Orjoro No. 5 has 3187 residents (NBS, 2012, 2018). This study used 103 sample sizes, 96 out of 2563 households obtained from three villages as follows, 22 from Losinyai village, 28 from Orjoro no.5 village, and 46 from Shambarai Sokoni village. Both closed and open-ended questionnaires were used to acquire the required information from the households. The questionnaire covered several aspects such as socioeconomic and demographic information, forms and causes of climate change, and adaptation measures.

Questionnaire pre-testing was done to reflect the condition during the full-scale implementation (Opiyo *et al*., 2011). Four research assistants were trained and used to pre-test the questionnaire, and the average time for pre-testing was approximately 30 minutes. After the pre-test, the final revised questionnaires were readily duplicated for data collection. The same research assistants were used in questionnaire administration. The key informant interviews were conducted to collect data on the stated theme; the aim was to capture the experience from government officials and community leaders. The respondents include village chairpersons, Ward Executive Officers, and Ward livestock field officers. The reason behind the use of this method was to capture the knowledge and experience from the appropriate government officials and community elders.

Weather data

The precipitation and mean temperature data were collected from Tanzania Meteorological Agency (TMA). During data quality assessment, the data from 1985-2016 were selected and used during analysis; the selection criteria were data continuity and the absence of abnormal high Fig.s.

Data analysis

The household survey data were analyzed using the IBM statistical package for social science v25. Data cleaning was done prior to analysis, and errors identified during data collection were collectively discussed and rectified.

Quality assurance

Several measures were employed to ensure data integrity, quality, and reliability. Data collection research assistants were trained and examined before recruitment, and then pre-testing of the questionnaires was done and evaluated before the primary data collection activities. Furthermore, the respondents were asked for their willingness to be interviewed, and those who accepted were the only interviewed. Also, data cleaning was done before the beginning of the data analysis process.

Results and discussion

Precipitation and temperature trends in Simanjiro

The trend of rainfall

The rainfall pattern for the past three decades has been fluctuating over time, but the general trend shows a decrease in rainfall by 7.2mm/year (Fig. 2).

A similar decreasing trend in northern Tanzania has been reported in several other studies (Hemp, 2005; Otte *et al.*, 2016; Said *et al.*, 2019). The fluctuation of rainfall in other parts of Tanzania has been reported elsewhere (Shemsanga *et al.*, 2010).

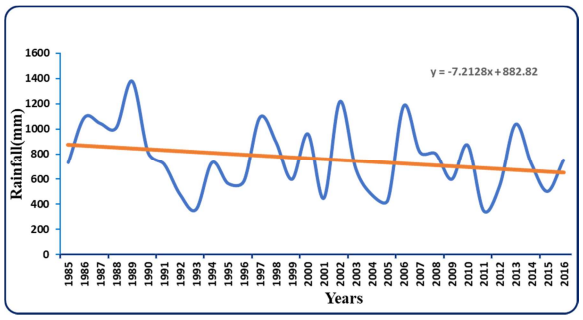

Fig. 2. Trend of Annual rainfall trend in the Manyara region.

Trend in Temperature

The annual average temperature trend in the Manyara region for the past three decades is reported in Fig. 3. The temperature trend for the past three decades fluctuated over time; however, the overall temperature trend increased at a rate of 0.02 C/year. Many scholars have also documented this variation of temperature over time in other areas of the country (Cohen *et al.*, 2007; Hemp, 2005; Otte *et al.*, 2016).

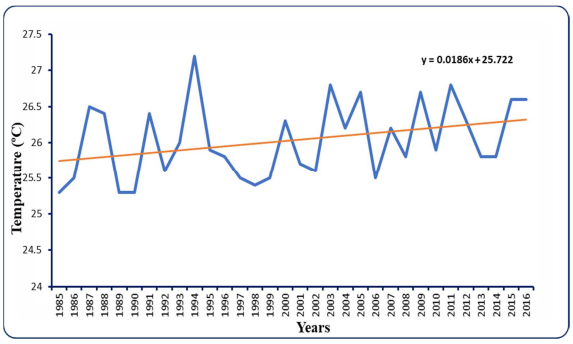

Fig. 3. The Mean Temperature trend in the Manyara region.

Community perception on the drivers of climate Changes

In all surveyed villages, most respondents mentioned deforestation and charcoal making as the major factors contributing to climate change. Other responses mentioned were industrialisation and overstocking. However, some of the respondents mentioned God's wish as a factor contributing to climate change.

This indicated that some villagers were not aware of climate change and its causes; thus, the need for climate change education will be important to increase community understanding of climate change and its impacts. These findings imply that the rate of environmental degradation, particularly the cutting of trees, is high due to anthropogenic activities, including charcoal making. This is due to the fact that these villages, especially Orjoro no. 5 and Losinyai, are very close to Arusha Urban, which offers a good market for charcoal (Fig. 4).

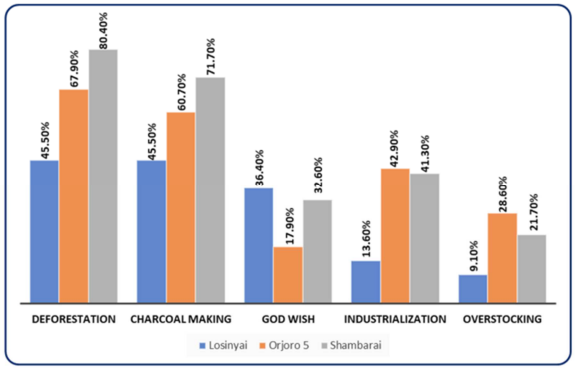

Fig. 4. Community perception on the causes of climate change.

Community perception on the effect of Climate Change

The effects of climate change on pastoralists are drought, loss of pasture, pests and diseases, an increase in land-use conflicts and family separation. The findings show that the effect varies from one village to another (Fig. 5). In Losinyai village, most of the responses (86.4%) mentioned pests and diseases as the major effect of climate change, followed by drought and other effects. This implies that the village did not have enough grazing land to cope with the challenge of pests and diseases, especially during the drought. Most of the livestock are kept and graze in a small area, hence influencing the spread of diseases. However, in the rest two villages (Orjoro no.5 and Shambarai Sokoni), most of the responses mentioned drought as the main effect of climate change on pastoralists (85.7 and 87%). This was also emphasized by the Ward Extension Officer of Orjoro no. 5 ward during the key informant interview.

He stated that "*In this ward generally livestock keeping is faced by different challenges but the main are drought, pests and diseases. Pastoralists are the most vulnerable because they keep their livestock locally without considering good livestock principles like livestock vaccinations*". This complies with the study done by Rukwaya (2016), who reported that climate change has negatively affected livestock keepers through shortage of pasture, an increase in drought, shortage of water sources and pests and diseases.

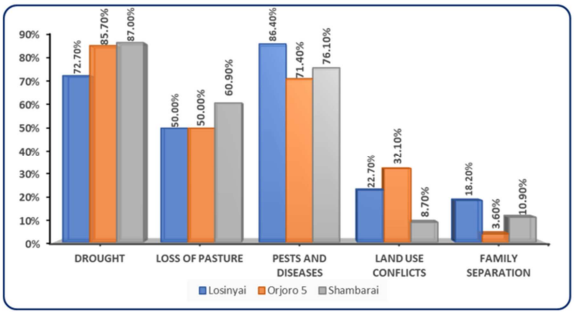

Fig. 5. Community perception on the effects of Climate Change.

Traditional Adaptation Strategies Taken by Pastoralists

Traditional adaptation measures mentioned by pastoralists are presented in Table 1. A high proportion of the members are moving cattle to wetland areas in all wards, the highest proportion being 97.8% in Shambarai Sokoni ward.

This proportion reflects the reported death of livestock in pastoral areas, especially during drought, reducing pastures (Rukwaya, 2016). The rest of the population (50-57.%) of the community members across all the wards store crop residuals for use in dry seasons. Other measures taken include buying dry grasses, destocking, restoration of pasture, mixed farming, keeping resistant breeds and construction of cattle water dams.

In Losinyai Village, the most mentioned traditional adaptation measures or strategies are moving cattle to wetlands (86.4% responses) and restoring pasture (59.1% responses). This implies that most pastoralists rely on moving their cattle to resource points as the major strategy to maintain their livelihood and escape from the effect of climate change.

These findings are consistent with the reported scenario in Mkuranga districts (Rukwaya, 2016); the report shows that migrating from dry to wetland or near the River is one of the strategies used by pastoralists to cope with the impact of climate change.

Table 1. Traditional adaptation strategies taken by pastoralists.

Adaptation strategy taken by Pastoralists	Ward name		
	Losinyai (%)	Oljoro no.5 (%)	Shambarai Sokoni (%)
Moving cattle to wetland areas	86.4	96.4	97.8
Storing crop residuals	50.0	57.1	56.5
Buying dry grasses	22.7	14.3	43.5
Destocking	22.7	39.3	21.7
Restoration of pasture	59.1	42.9	41.3
Mixed farming	22.7	14.3	17.4
Keeping resistant breeds	9.1	7.1	4.3
Construction of cattle water dams	27.3	28.6	17.4

Community perception on the effectiveness of traditional adaptation strategies

Most of the respondents in all villages accepted that the traditional adaptation measures are effective (Fig. 6); however, other respondents were not in agreement with the effectiveness of these strategies. This mixed feeling shows the need for scientific intervention to help these communities adapt to climate change. On the other hand, they imply that traditional adaptation measures helped pastoralists to cope with land use and climate changes. However, they face many challenges, including blockage of livestock routes, the spread of pests and diseases and corruption that limit their effectiveness.

Furthermore, there has been almost equal agreement and disagreement on the effectiveness of local adaptation measures in Orjoro no.5 ward. The death of livestock may be attributed to the previous year due to dryness, which posed a shortage of pasture and water even though traditional adaptation measures were applied.

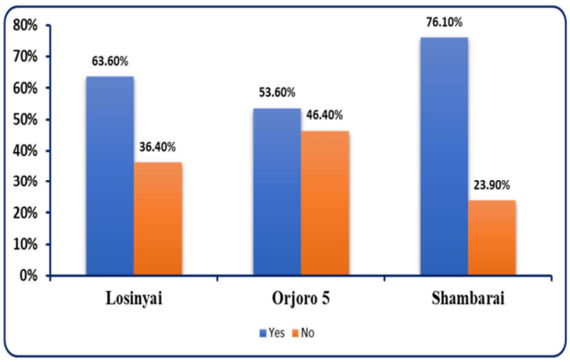

Fig. 6. Effectiveness of traditional adaptation strategies.

Challenges facing the use of local adaptation Strategies

Several constraints or challenges were mentioned by pastoralists that constrain them in using traditional adaptation to climate change and land use changes. The commonly mentioned challenges are closing the cattle grid or trail, poverty, corruption, and the current village land use plan. Other challenges are land use conflicts, pests and diseases, insufficient knowledge on storing dry grasses and crop residuals and scarcity of dry grasses and crop residuals.

The constraints with the highest frequency in all villages are closing of the cattle grid, corruption and poverty (Fig. 7). This reflects that the livelihood of the pastoral community is highly afflicted by closing the cattle grid. This closure limits the free movement of cattle from one village, ward, district or region to another for searching pasture and water, especially during drought and loss of grazing land hence increase of livestock death.

The interview with the ward livestock officer revealed that the rapid increase in crop cultivation activities in the wards that go together with plantation agriculture blocks the livestock routes (grid).

This blockage limits the movement of livestock to other areas with enough pasture and water. Apart from the blockage of the cattle grid, poverty also limits pastoralists to use appropriate adaptation measures. The rapid opening of farms for crop production has caused an increase in conflicts among communities. Sanga *et al.* (2013) reported similar results on small scale farmers of Pangani who found out that the main challenge constraints to climate change is lack of capital to use appropriate adaptation measures.

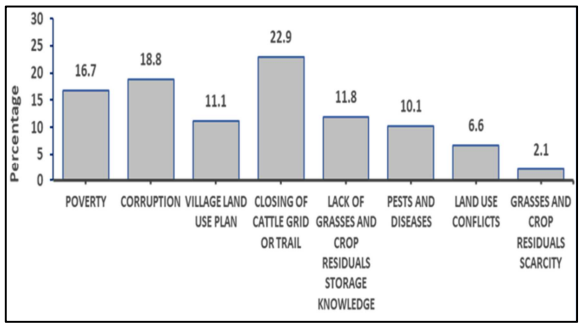

Fig. 7. Challenges facing traditional adaptation strategies.

Community perceptions on the improvement of traditional adaptation strategies

The study found many constraints in climate change traditional adaptation strategies. The respondents suggested that the government, particularly local government, should ensure opening cattle grid or trails, protecting grazing land, providing grass seeds, providing modern livestock keeping education and construction cattle water dams (Fig. 8).

However, in all villages, the most mentioned way of improvement is the protection of grazing land followed by opening a cattle grid or trail. This implies a big challenge of grazing land encroachment in all villages by crop cultivators who opened big farms in the pasturing area and blocked livestock routes (cattle grid). This phenomenon creates limitations to traditional adaptation measures used by pastoralists, including pasture restoration and movement of cattle to wetlands during drought conditions. Also, community elders supported this suggestion stating that *"If village leaders effectively control the encroachment of grazing land, we will manage to do*

pasture restoration and grazing rotation as we did many years ago. This helped us to protect our livestock from the shortage of pasture and water during the dry season".

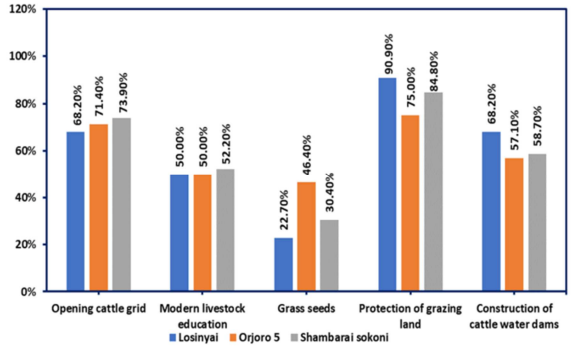

Fig. 8. Community perception on the improvement of traditional adaptation strategies.

Conclusion and recommendations

Climate change afflicts the life of the Maasai communities in many ways; this phenomenon has driven the oscillation from transhumance to agro-pastoralism along the Maasai steppe. Some of the initiatives used by Maasai communities to adapt to the ongoing change include moving cattle to wetland, buying hay, storing crop residuals, pasture restoration and keeping resistant breeds. However, moving cattle herds to wetland areas is highly affected by establishing large farms that block the livestock grid. This study suggests improving traditional adaptation strategies by opening a cattle grid, providing modern livestock keeping education, providing grass seeds, protecting grazing land, and constructing cattle dams. Also, the study suggests the integration of the local adaptation techniques into the current scientific climate change adaptation techniques.

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