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RESILIENCE STRATEGIES FOR CLIMATE CHANGE: EVIDENCE FROM AGRO-PASTORALISTS IN KITETO AND KILINDI, TANZANIA

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Abstract: Climate change and its variability threaten food security globally, making life uncertain, especially among agro-pastoral communities living in fragile semi-arid areas. This trend has necessitated the exploration of the potential designed and developed pathways and the emerging challenges which reduce the adaptive capacity of agro-pastoralists. This study investigates innovative pathways and challenges facing agro-pastoral communities in adapting to climate change and variability effects on crops and livestock production in semiarid areas of Kiteto and Kilindi Districts. A mixed-method research approach under a correlation case study design was employed. Primary data were collected using a household survey which sampled 362 households, Focus Group Discussion (n=6), In-depth interviews (key informants) and field visits. Descriptive statistics and thematic analysis were used in analysing and presenting the findings. The study results indicate that agro-pastoral communities have observed a decrease in rainfall and an increase in temperature trends that were linked to reduced livestock, cereals and pulses crop production thus affecting the agro-pastoral community's food security status. The study identified innovative pathways as a response to reduced livestock, cereal and pulse crops production which includes growing drought-tolerant crops, practising intercropping, livestock seasonal mobility, traditional grazing management system through by-laws, pastures rotational uses and traditional water reservoirs (Mboutu). Furthermore, the study identified several challenges to overcoming declining livestock production and crop yields, which include inadequate financial capital (91%), droughts (85.4%), unpredicted weather patterns, (74.7%), emergency of new livestock diseases (50.3%), a lack of reliable weather information (44.2%), low livestock prices (40%), insufficient and delayed delivery of agricultural equipment (37%). All these challenges reduced the resilience capacity of agropastoralists. To ensure the sustainability of fragile dryland communities, this study recommends purposeful institutional intervention plans and increased income diversification as well as more capacity-building activities for increased awareness of climate change adaptation practices in semiarid areas of Tanzania which will increase agro-pastoralists resilience.

Keywords: Agro-pastoralism, Resilience, Climate change and variability, Pathways, Food security

1.0 Introduction

Climate change and variability is a global phenomenon while adaptation is largely site-specific, as site-specific issues require site-specific knowledge. Experience has shown that the identified pathways do not necessarily translate into changes because there are context-specific issues such as social, financial, cultural, psychological

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and physiological barriers to adaptation (IPCC, 2007). Climate change and variability have already impacted the majority of developing countries particularly Sub-Saharan Africa, including Tanzania. Increasing vulnerabilities and impacts on these countries have been attributed to low-income levels and low technology to be able to adapt to environmental changes (IPCC, 2001), however, there are variations in vulnerability. While all places globally are likely to be affected by climate change and variability effects, semi-arid areas of the world, Africa in particular such as those in eastern and north eastern Tanzania seem to be more vulnerable to these effects due to their prolonged drier conditions, high poverty levels among agro-pastoral communities, poor technology use and lack of viable weather information on appropriate measures (UN, 2009). According to the warning by the United Nations Development Programme (UNDP), the progress that has been made in human development over the last two decades may be slowed down or even reversed by climate change and variability as new threats emerge to water resources, agricultural and livestock production, nutrition and public health (UNDP, 2008).

Hence, building resilience is paramount to a great extent and can be achieved by reducing vulnerabilities and increasing the adaptive capacity of the local community, enhancing the resilience of the livestock systems of increasing the capacities of agro-pastoralists to adapt to different types of shocks. Studies show that the majority of households in the arid and semi-arid regions have limited assets and scarce resources to use in developing pathways to increase resilience and reducing climate change-induced shock or stress which results in more food insecurity through reduced crops and livestock production (Ifejika, 2010; Silvestri, et al., 2012). However, despite the limited adaptation capacity, many agro-pastoral communities using their indigenous knowledge system (IKS) have long been coping and developing various pathways that have helped them to cope and survive the impacts posed by changing weather conditions in arid and semi-arid lands (ASAL's) (FAO, 2008). In times of droughts and dry spells, agro-pastoral communities in these areas have reported changes in their farming strategies and increased livestock mobility to cope with these changes. Several pathways have been implemented including growing drought-tolerant crop varieties, practising intercropping, buying food, reducing food intake and social gatherings, selling livestock, livestock seasonal mobility, traditional grazing management system through by-laws for pastures conservation/rotational use and traditional Maasai constructed water reservoirs for livestock (Mboutu).

As a response to climate change and variability effects, several governments, particularly in Africa have introduced and established policies, plans and programs to slow down these effects across different sectors of production. However, all these efforts have become less fruitful due to the existence of various limitations such as poor access to weather information and knowledge at local levels, inefficient strong institutions, limited capacity building on climate change issues, limited economic resources and limited infrastructure (Suckall et al., 2014). According to Arendse et al., (2010), all these in turn limit the effectiveness and sustainability of pathways that are locally developed to address the reduced productivity of the agro-economic systems.

Tanzania has made several efforts to minimize the adverse effects of temperature and rainfall variations on various sectors including agriculture and livestock. The government and many non-government institutions have, to some extent, been supporting agro-pastoral communities through the provision of weather forecast information, education on good farming and livestock keeping practices, and food aids during chronic or transitory food shortages as well as improved crop seeds and livestock varieties. However, the coverage of all these efforts is very limited to remote rural areas, especially among the agropastoralists who dwell in fragile remote areas which lack accessibility or good infrastructures such as roads. Despite the attempts made, several challenges have been

noted over time particularly, slow implementation of different funding programs, lack of sectoral coordination in the water, agriculture, and land sectors (lacks multisectoral integration), inadequate national and local capacity building, increased corruption, inadequate skills and low technology, shortage of extension officers, and cultural barrier have been the causes for resistance to change (Shemsanga et al., 2007).

Even though institutional challenges in combating the effects of climate change and variability in most semi-arid areas of Tanzania have been pointed out, several pathways towards changing climate have been developed using both indigenous and modern knowledge. However, little is known as to why agropastoral resilience is still very low to the extent of increasing their vulnerability, particularly in the most vulnerable and fragile semiarid areas of the country. This study, therefore, intends to bridge this knowledge gap by examining the developed pathways and the new emerging major challenges facing agro-pastoral communities in implementing local pathways that have been increasing their resilience by reducing their vulnerability in dryland areas. The information gathered from this study is expected not only to add knowledge to the existing literature but also to be used by various stakeholders like the government, policymakers and non-government organizations to address issues related to coping strategies for increased resilience to the impacts of climate change and its variability among agro-pastoralists in semi-arid dry lands (ASAL) to enhance household food security.

2.0 Methodology

The present study was conducted in semiarid areas of Eastern and Northeastern Tanzania of Kilindi and Kiteto Districts in Tanga and Manyara regions respectively, Tanzania (Figure 1). The study areas were chosen because of their typical characteristics of semiarid conditions together with the existence of repeated transitory food insecurity among agro-pastoral communities whose main occupations were livestock keeping and cultivation of local cereal and pulses crops including Maize and Beans, and livestock such as cattle, goats and sheep (KDC, 2020).

Kiteto District is generally considered an Arid to Semi-arid type of climate. The average day and night temperature in the district is between 25°C to 35°C. To a large extent, the type of climate is directly related to the topography of the area. The hot months are July, August, September, October and November. The Cool months are March, April, May and June. Although there are remarkable variations in the amount of precipitation; the district is receiving an average of 350mm - 700mm of rainfall. According to KDC (2020), Kilindi District is a semi-arid type of climate with an average annual rainfall of 500mm ranging from 400mm to 700mm, and temperature ranging from 22°C to 30°C. Kiteto has dual periods of unreliable rain seasons comprising short rains between October to January and long rains from February to June. The cold months are May to July, while the hottest months are from August to February.

This study employed a correlation-case study design constituting a mixed method research approach. Mixing both quantitative and qualitative methods aims to capture the breadth, depth and meaning of the phenomena under study (e.g. qualitative quotes support or challenge statistical results). A mixed research approach was applied in this study to provide triangulation and complementarities of the research findings (Creswell, 2013). Purposive sampling was used in the selection of the study area (Kiteto and Kilindi Districts) due to their semiarid vulnerability conditions, thus being more prone to climate change and variability. Purposive sampling was used in the selection of the study districts, wards and villages based on agroecological distribution. The selection of the studied wards and villages was based on the criteria of arid semi-arid conditions/droughts, food shortage history and frequency of receiving food aid as well as habitation by livestock keepers.

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Simple random sampling was applied in the selection of the household heads and heads of boma (unit of study). Hence under this study, the concept of boma (locally known as almare) was adopted as a unit of analysis of the agropastoralists specifically Maasai communities, while the traditional "household" was maintained and applied in the analysis of non-pastoral or agro-pastoral data from non-Maasai communities such as Zigua and Ngu societies. The target group of the study was heads of households. Household heads in each study village were randomly selected depending on the sample size required for each village.

Primary data were mainly collected by using a household survey which sampled 362 households, Focus Group Discussion (n=6) for every study village, in-depth interviews (key informants) and field visits (field observation. Key informants, particularly agricultural and Livestock Officers, Livestock Field Officers, village leaders and elders were purposively selected for the study due to their potentiality for the research theme. Also, focus group discussions (FGD) and in-depth interviews were conducted in all study villages aiming to capture qualitative information. Simple random sampling was used in the selection of agro-pastoral communities. The sampling frame of this study comprised 3843 households selected from six villages, namely Saunyi, Kwekinkwembe, Erelai, Makame, Ndedo and Ngapapa. Based on the sampling frame above, 362 households were selected by using a formula proposed by Israel, (2009). The formula which is based on a 95 per cent confidence level and P = 0.05 is as follows,

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

Where n is the sample size to be calculated, N is the total population of the study (village households' statistics), and e is the level of precision or margin of error measured by a probability scale of 5 per cent. Therefore, plugging data into the formula, the following was in order;

$$n = \frac{3843}{1 + 3843(0.05)^2}$$

n □ 3843 / (1 □ 3843 □0.0025)

n □ 3843 / 10.6075

362 *n* =

The calculated sample size was used to compute the proportion number of households in all the study villages that were determined by the number of households in each village. The formula used read as;

$$nh = \frac{Nh}{N} n$$

This resulted in a proportional sample size selected in each village where Saunyi was represented by 79 household heads, Kwekinkwembe 85, Erelai 41, Makame 71, Ndedo 47, and Ngapapa 40 amounting to 362 household heads used in the sample size. Primary data were the main source of information for this study based on qualitative and quantitative approaches and were also collected through focus group discussion (n=6 for all the study villages),

in-depth interviews (n=10), field observation through transect walks which were deemed necessary to confirm some of the issues raised during in-depth interviews, focus group discussions and structured questionnaires for the socio-economic survey (n=362). Both closed and open-ended questionnaires were administrated to agro-pastoral communities and government officials who were key informants. In-depth interviews, FGD and field observations were used to complete and control the quality of information collected by the household socio-economic survey. Secondary data were obtained from published and unpublished documents and reports from different sources including rainfall and temperature data from the Tanzania Meteorological Agency, crop yield data (maize and beans) livestock data (cattle, goats and sheep) from the National Bureau of Statistics, the Ministry of Agriculture, Food and Cooperatives; and the District Agricultural and Livestock Development Offices (DALDOs). Different publications, books, theses and journals from the libraries of the University of Dar es Salaam (UDSM), Institute of Resource Assessment (IRA), government policy documents and websites were reviewed.

In all, the collected information was on perceived impacts/vulnerability, innovative pathways and challenges (Majule et al., 2009; Myeya et al., 2018).

Quantitative data collected from the questionnaire survey were edited to improve the quality of coding. The data analysis started with the data summarization process which was carried out through the use of two software packages for data analysis namely Statistical Package for Social Sciences (IBM SPSS version 20) and Microsoft excel 2010. The software packages enabled the data to be summarized using summary statistics (frequencies and percentages) which simplified the description and presentation of the study findings by showing the patterns and trends of rainfall, temperature, livestock and crop yield. The regression technique and R-square software (R^2) were used to examine patterns and trends of the climatic variables against pastures and livestock production. Tables and figures were used to present the findings of qualitative data from focus group discussions, in-depth interviews and field observations which were analysed through thematic analysis.

3.0 Results and Discussion

3.1 Major Livelihood activities in the Study areas

Livestock keeping is a primary livelihood activity carried out in Kiteto District (KDC, 2018). The economy of this district depends almost entirely on livestock and crop farming on a small scale. Animals kept are cattle, goats, sheep, donkeys and chicken which are mostly reared by the Maasai; major crops grown are maize, beans, sunflower, cassava, millet and finger millet. Agropastoralism in the district accounts for 60 per cent, crop production for 22.8 per cent and pure pastoralism for 17.2 per cent. Hence, agro-pastoralism is mostly the dominant livelihood activity. Notably, agriculture is characterized by low productivity due to unreliable rainfall (URT, 2007c; BDC, 2006).

In Kilindi District, agriculture is the primary activity, followed by animal keeping (KDC, 2018). Agriculture is reported to account for more than 60 per cent of practitioners in the district with the largest number of smallholders who also keep animals (agro-pastoralists, (amounting to 40%), and is the main producer in the region. The National Food Reserve Authority (NFRA) has singled out the district as the main collector of food crops in Tanga region (URT, 2012). This implies that the majority of the people in the area are smallholder farmers characterised by agro-pastoralism that depends on rain-fed agriculture which is also vulnerable to climate change and variability effects. Major crops grown are maize, beans, sunflower, cassava, sweet potatoes, millet and finger millet, mangoes, bananas, and sugarcane. However, currently, there is the introduction of new crops such as cashew nut,

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Haricot bean, pigeon peas and cowpeas as drought-resistant crops. The animals kept are cattle, goats, sheep, and donkeys

The study was confined to two agro-pastoral districts namely Kiteto and Kilindi Districts, taking three wards from each district based on differences in agroecological zones. About six study villages were selected, one village from each ward, namely Saunyi, Kwekinkwembe, Erelai (Kilindi District); Makame, Ndedo and Ngapapa (Kiteto District). The occupation performed by the household heads determines the income levels which in turn, influences the vulnerability of the household to climate change and variability effects.

Livelihood diversification has been recommended in this era of climatic stresses as it increases resilience. The findings show that agro-pastoral communities have increased livelihoods diversification and engaged in various activities other than keeping animals only including mixing both keeping animals and cultivation, petty business (5.1), hunting (4.4%), beekeeping (4%), collecting and selling firewood (1.7%), Arts and craft works (1.4), making and selling charcoal(1.2%), casual labour (0.8%), wage employment and mining (0.4%). Increased diversification among agro-pastoralist means increased resilience towards responding to stresses caused by climate change and variability in semi-arid areas

3.2 Agro-pastoralists perceived the effects of Climate Change and Variability

Field results indicated that climate change and variability have affected agro-pastoralists in the study areas from as early as the 1980s' and continue this category of people to date. Also, all the villages studied were observed experiencing the impact of climate change and variability. The findings indicate further that the majority of the respondents mentioned a decline in the number of their livestock to about 91.1 per cent as the major indicator of climate change and variability in the study areas. The decline in the number of animals is based on the extent of food insecurity that has been faced by the communities for six years consecutively. This was in turn linked to decreased rainfall amount and duration which affect pastures and water availability to animals.

Moreover, increased droughts were noted to be the second felt impact indicator reported by 89.1 per cent of the respondents. According to the respondents, increased droughts, which have been recurrent for a very long time, had adverse effects on water and pastures which forms the basis for their animal feed. The recurrent food shortage was also one of the major impacts of climate change and variability in Kiteto and Kilindi Districts as reported by 87.2 per cent of the respondents. According to the respondents, prolonged droughts result in failures of crops such as maize and beans as well as deaths of their animals, especially cattle and goats which they depend on for food through meat, milk and blood, and have been facing food insecurity since the 1990s. Apart from depending on cattle directly for food, they also sell the animals to buy other food items such as sugar and maize flour from shops. However, they now fail because of their low income as the price of cattle and goats during the dry season becomes very low.

The results show further that 86.5 per cent of the respondents reported the emerging new livestock diseases as a cause of food insecurity. The agropastoralist emphasized that the changing environment has led to the emergency of new animal diseases such as Rinder pests (locally known in Maasai as Olodwa), Heart water (locally known in Maasai as Olmiro) and Anaplasmosis (locally known in Maasai as Emonywa). These diseases never existed before in their locality. In addition, old diseases such as Lung Sick CBPP (known in Maasai as Olikipei) Tsetsefly/Ndorobo, Anthrax, East Coast Fever (Ndigana kali, ECF) and Foot and Mouth disease (Alerobi) have also been killing their animals in large numbers.

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3.3 Pastures status in Kiteto and Kilindi Districts

The quantification of pastures/grazing lands size depended on the category of livestock (cattle, goats and sheep. Hence the size of pastures presented graphically based on livestock category and their trends and patterns of grazing land varied. Kiteto District shows a decreasing trend in grazing lands in all livestock categories, whereby cattle pasture area is explained by 93 per cent (R2 =0.9303) of the observed variance for the entire study period and the decrease is by -1018.7 hectares y -1. The decrease for goats pastures is explained by 89 per cent (R2 =0.8862) of the observed variance in the whole study period, and the decrease is by -60.586 hectares y -1 sheep the decline of pastures is explained by 83 per cent (R2 =0.8365) of the observed variance in the whole study period, and the decreased is by -77.046 hectares y -1.

Kilindi District also indicates a decline in pasture areas among livestock categories except for pastures area for goats which shows a positive increase. The results revealed variability in grazing land, cattle pasture area decrease is explained by 62.2 per cent (R2 = 0.6222) of the observed variance for the entire study period and the decrease is by -338.89 hectares y -1. Also, the pasture area for sheep declined by 3.7 per cent (R2 =0.0376) of the observed variance for the entire study period and the decrease is by -57.339 hectares y -1. While pasture area for goats increased positively by 96.7 per cent (R2 =0.1377.3) of the observed variance for the entire study period. Theoretically, risk hazard and political economy theory justify this study in facilitating the assessment of the effects of internal factors on a vulnerable system and the role of the external factors on exacerbating or protecting the system from hazards. IPCC (2007) vulnerability in an integrated approach focuses on the character, magnitude, and rate of climate change to which a system can be exposed, its sensitivity and its adaptive capacity. The vulnerability and exposure of an object are dynamic and depend on economic, social, demographic, cultural and institutional factors (CDKN, 2012:04). Hence, agro-pastoral communities are most vulnerable because of being exposed to the risk semi-arid environment.

3.4 Agro-pastoralists' perceptions of long-term changes in Rainfall and Temperature

About 71.1 per cent of the respondents cited increased temperature as a risk factor for food security exposed to people in semi-arid areas. According to agro-pastoralists, the temperatures are very high affecting the growth of pastures and the construction of traditional wells for animals and domestic uses. The respondents reported that nowadays dry spells have increased as compared to the previous years. Based on their experience, dry spells that happened in February lasted for two to three weeks. Nowadays, dry spells are unpredictable as they extend even in January (crops and pastures growing season), thus affecting the whole growing season and pastures. The study analysed agro-pastoralists perceptions of temperature and rainfall variability and change over the past 30 years. The results show that the majority (91.4%) of the respondents believed that temperatures were increasing. Villagewise, more than 85 per cent of the agro-pastoral communities in each village reported noting increased temperature rates. Agro-pastoralists reporting an increase in hot days indicates that generally, the temperature was on the increasing trend. Also, Lema and Majule, (2009) reported a similar finding in Manyoni District.

Apart from temperature trends and patterns, the majority (81%) of agropastoralists noted a decreasing rainfall while about (3.6%) reported noting no changes. A decrease in rainfall was explained based on rainfall amount, duration, distribution and intervals. Agro-pastoralists reported further that rainfall onset and cessation dates (seasonal changes) were unpredictable (Fig. 5). Similar observations are reported by other studies in various parts of Africa. For example, studies by Deressa et al., (2011), Lema and Majule (2009), Swai et al., (2012) and IPCC (2007) indicate that there has been a decline in rainfall amount in other parts of Tanzania and Africa in general.

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Swai et al., (2012) also noted that rainfall has been more erratic, more unpredictable and continues to decrease in amount in Bahi and Kondoa Districts, Tanzania.

3.5 Innovated Pathways for enhancing Climate Change and Variability resilience among Agro-pastoralist in Kiteto and Kilindi Semi-arid areas

As a result of the observed changing climate and variability through increased temperature and reduced rainfall, seasonal changes, particularly in semiarid areas of study districts, various pathways were investigated. The Agro-pastoral communities have been described as "masters of innovative traditional adaptation strategies in drylands," actively relying on variability to maximize animal productivity during periods of plenty and scarcity and carefully managing rangelands during periods of food shortage (Msangi et. al., 2014). The findings from the study revealed that agro-pastoralists in the study areas employ several highly specific risk-spreading strategies to safeguard their herds and family food security in the face of unpredictable and sometimes extreme climatic change and variability events such as drought, temperature rise, emerging livestock disease and shortage of water and pastures. Increased sustainable innovative pathways to increase resilience upon climate change and variability for ensuring the rational use of the natural resource base on which the herds depend and also build strong social networks and food security. Overall, the main innovative pathways in order of importance were seasonal livestock mobility, construction of traditional wells or points, the use of traditional by-laws for pastures conservation or rotational use, the reduction of the number of stock by selling and using them to transport water from traditional wells.

Moreover, 60 per cent of the agro-pastoralist (Fig.6) reported having introduced pastures conservation or rotational traditional water points (Njoro) and reducing livestock numbers by selling them to buy food. Generally, based on the findings in Figure 6, agro-pastoral communities dwelling in fragile semi-arid areas are surviving in their local environment using their indigenous knowledge systems (IKS) which have made these communities survive for a long time despite the harsh environments which have been increasing in severity.

3.6 Challenges towards agro-pastoral communities innovative Pathways on overcoming Climate Change and Variability effects

Even though agro-pastoral communities have been developing different coping and pathways (being referred to as good adaptors) to increase their resilience, the impacts of climate change are increasingly multiplying affecting the main livelihood activities of agro-pastoral communities, particularly agriculture and livestock, hence causing food insecurity. These challenges have been limiting agro-pastoral communities developing capacities for adaption to increase resilience to their fragile dryland's environment.

The challenges facing agro-pastoral communities are many, complex and intertwined. Social and economic differentiation affects how agro-pastoralists cope with harsh environments in dry lands. Generally, in this study, the challenges to climate change and variability are grouped into two major categories, those related to physical and environmental factors and those related to institutional arrangements such as policies. Therefore, the adaptive capacities of agro-pastoral communities towards the effects of climate change and variability are dynamic and are influenced by the factors discussed in Table 2

3.7 Physical Environmental Limiting Challenges

3.7.1 Droughts

The study showed that agro-pastoral communities are aware of the limits and challenges that affect their innovative pathways to deal with the current changing climatic effects. The findings indicate that about 85.4 per cent of the respondents perceived drought as a major physical barrier which limits farming and animal-keeping

activities and adaptation strategies to climate change and variability. In both study villages, agro-pastoral communities believed that drought conditions have increased than they used to be, and it has now become the major barrier to many of the traditional pathways that are currently being implemented in the villages. A similar observation was reported in a study by Juana et al., (2013) indicating that drought is perceived as the major factor limiting most adaptation strategies to climate change in dryland environments.

3.7.2 Unpredicted Weather Patterns

Unpredicted Weather Patterns were ranked the second limiting physical factor by 74.7 per cent of the respondents. A comparison across villages indicate that unpredicted weather patterns were not uniformly reported across the study villages in both study districts. Therefore, some villages reported the incidence more highly than others due to variations in the physical environment and environmental awareness. Kwekinkwembe was ahead in reporting the unpredicted weather patterns (93.3%) whereby unreliable rainfall, unpredicted onset and cessation of seasons are among the major limiting physical factors to climate change and food insecurity. This was followed by Ndedo (92%), Ngapapa (86%), Saunyi (85.5%), and Erelai (79.1%) and lastly Makame (61.3%). According to KDC (2017) report, the district now experiences unpredictability of both rainfall and temperature more than used to be the case in the past. Inter-season dry spells have been varying in time and space in Kilindi district for almost 12 years, for example, long droughts in 2008/2009 and 2015/2016 affected the district's proper planning for agricultural seasons, resulting in shrinkage of the growing season, loss of agrobiodiversity, and drying up of livestock pastures and water resources.

3.7.3 The emergency of new Livestock Pests and Diseases

This factor was ranked third in the overall score with 50.3per cent, the assessment of the emergence of new livestock diseases based on agropastoralists perceptions and observations on the presence of diseases among their livestock whose symptoms include reduced milk production, poor health of their animals and death incidents of large numbers of their livestock throughout the year during both dry and wet seasons. Livestock diseases can cause significant herd losses, translating into large declines in agro-pastoral income which impact negatively availability of food.

The most mentioned diseases were Heartwater (HW), Rinder pests (Olodwa), Anaplasmosis (Emonywa), Olmiro (kizunguzungu), and Ngiliama caused by the lack of pastures during the dry season, Nunuku is treated by ashes (majivu), romorojo and Lumpy skin disease (olukruku) for goats. Also, they cited old diseases such as Foot and mouth disease (Alerobi), East coast fever (ECF)/ Ndigana kali, Anthrax (Olikipei), Babesiosis, Trypanosomiasis, Blackquater (BQ) and worm infections which still kill their livestock despite using their local treatment. During FGD, it was reported that livestock currently faced several diseases both new and old, and due to a large number of livestock they own, they were not able to buy industrial agrochemicals from shops, instead, they applied their local medicine which now days are not effective as a result a number of their livestock deaths is increasing.

3.8 Institutional arrangements Limiting Challenges

3.8.1 Shortage of Financial Capital

Normally, any innovative pathway is costly, hence resource-poor agro-pastoral communities with low adaptive capacity against climatic stresses are more vulnerable. The agro-pastoral communities in the study areas mentioned limited financial capital as a major constraint for not taking and implementing particular adaptation strategies. Low financial capacity at different levels among agro-pastoral communities, limited purchase of livestock medicine for treating emerging diseases as well as farming inputs are other barriers to adapting to climate

change. About 80 of the respondents across villages mentioned the shortage of capital as a limiting factor in the adaptation to climate change and food insecurity. However, there was a variation in reporting due to differences in the economy. Saunyi led by 94 per cent of the respondents reporting a shortage of capital as a barrier to adaptation practices followed by Makame (92%), Kwekinkwembe (91.1%), Ndedo (88%), Erelai (86%) and Ngapapa (81.4%). Similar findings in a study by O'Brien et al. (2000) revealed that even though, agro-pastoralist had numerous portfolios of pathways which they were willing to apply; they were still hindered by limited incomes to purchase necessary livestock medics, farm inputs and equipment. For instance, according to agro-pastoralists, digging water wells or points/ Njoro, costs between Tsh 5 to 8 million; selling livestock, supplying one sack of maize to workers, and the construction takes three to four weeks, hence one with a few livestock will fail to own individual water point (Njoro). Therefore, funding for climate change and variability is vital for developing countries such as Tanzania to plan for and implement various pathways plans and projects. The agro-pastoralists have a slogan, "livestock will die during bad weather (dry season) but will recover during good weather (wet season)."

3.8.2 Low Livestock prices

During FGD, it was revealed that selling livestock especially cattle during the dry season is a loss because prices are low as cattle are normally very weak due to poor pastures and water availability. During a household survey (HHS), about 80 per cent mentioned low prices for their livestock especially during the dry season as a limiting factor to getting good money for investing in other pathways such as building water reservoirs (Mboutu), building water points (Njoro) and buying crop tolerant seeds and other agricultural inputs. According to McCarthy et al. (2000), in sub-Saharan African countries, about 25 million pastoralists and 240 million agro-pastoralists depend on livestock stocks as their primary source of income for their wellbeing, therefore, the prices stability of their livestock is very paramount as it is the main determinant of their survival in dry land areas. Therefore, agro-pastoralists should be educated to sell off their stock of livestock immediately on the onset of droughts and should sell mature and healthily livestock in good years or seasons and save money thus earned in savings accounts for use in seasons or years of drought.

3.8.3 Gender inequalities

Changes in socio-cultural practices, including changing gender roles, increased pressure on women and children as workload increases and breakdown of family structures (increasing women-headed households/bomas) as reported also by Kabote et al. (2013). Traditionally, men and boys in pastoral communities are responsible for grazing livestock while girls help their mothers at home. However, climate change and variability have caused overlapping of tasks between men and women in managing livestock. For example, during the study, women and girls were observed doing similar tasks which were not carried out during seasonal movements including grazing goats, and sheep. For instance, men are the ones who usually migrate with livestock and leave women and children behind; women are left alone with their families and to fulfil all the responsibilities for the family with additional farm work that is usually done by men. Women are involved in casual labour, small-scale businesses such as selling milk and artworks including decorating the Maasai dresses for sale, and agro-pastoral women are to ensure there is enough food for the family in the household and look after young children. The findings from FGD indicate further that during prolonged droughts, women move to very long distant places with their donkeys searching for water, carrying firewood, searching pastures for feeding calves and pregnant livestock that remain at home, a responsibility which was done by men/boys.

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3.8.4 Large Family households

In this study, about 65 per cent of the respondents reported having a very large number of families which stand as a challenge, especially during the dry season when food becomes very scarce. The households' sizes of the majority of the respondent ranged from 11 to 20 persons per household/boma. Therefore, the average household/boma size is 5.2 for Makame, 4.9 for Ndedo, 5.1 for Kijungu, 5.1 for Saunyi, 5 for Erelai and 5.2 for Kwekinkwembe implying that all study villages have greater household size than the National average household size which is 4.8. These higher average statistics in household/boma size are influenced by customary laws and culture of the Maasai community where the number of children and wives are indicators of wealth in the community.

3.8.5 Limited Technological Adaptation strategies

About 64.6 per cent of the respondents cited insufficient technology adaptation as main livelihood strategies in the era of climate change and variability as a challenge to livestock keeping and farming. The findings during FGD it was revealed that there is a need to integrate indigenous knowledge system with modern technologies such as pastures planting and conservation, adoption of crops droughts resistant, and land use planning among agro-pastoral communities due to increased new environmental changes that cause new stresses. Therefore, despite that agro-pastoralist are good adaptors to their semi-arid climates, the current impacts of climate change and variability on different livelihood activities have negatively affected food security. As Dungumaro and Hyden (2010) point out, educated people are in better health and often contribute to greater environmental changes by facilitating access to weather information and a means to the adaption to climate change and Forster economic development.

3.8.6 Lack of reliable Weather information

Reliable and valid weather information is very important in this era of climate change and variability. Lack of reliable and valid information or knowledge from official Government or private sources was one of the most important factors cited by 64.6 per cent across the study villages as a barrier to the adaptation to climate change. During FGD, unreliable meteorological information on the trend and patterns of weather specifically rainfall amount, distribution, intensity as well as temperature trends were reported as the most pressing constraints for adjusting erratic or reduced rainfall through changing planting dates and rotational livestock pastures. Also the argument that weather information which is rarely delivered to them for pre-harvest is very general and lacks specificity because the district is not uniformly having similar weather characteristics.

3.8.7. Land shortage (Grazing and Cultivation lands)

It is interesting that, ownership of land among agro-pastoral communities whereby land is owned communally, and wealth ranking were not mentioned as indicators of wealth. During FGD, land shortage was reported as a limiting factor in the adaption to climate change, however, they disagreed that a high number of their livestock was the source of the land shortage instead they pointed to smallholder farmers as a source of limited land, as smallholder farmers expand to pastoral livestock routes. The study findings show that land uses or cover changes during 30 years agricultural land has increased in all the study villages at the expense of forest, bushlands and grasslands. Hence, the remote sensed data support the Agricultural Officer that the expansion of agricultural fields by both smallholder farmers and agro-pastoralist themselves was a leading cause of land shortage, especially the grazing lands.

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3.8.8 Insufficiency of Agricultural and Livestock inputs and Equipment

During the household survey, about 43 of the respondents mentioned shortage and expensive and untimely delivery of agricultural subsidies (inputs and equipment) as some of the institutional limiting factors across the study areas. The in-depth interview with the District Agricultural Officer and evidence from the report on the number of inputs received in the district from the Department of Agriculture and Livestock Development office (DALDO) in Kilindi District confirmed that the number of vouchers received under the country's agricultural development strategy, Kilimo kwanza in Swahili (Agriculture First), was not sufficient, and has even been decreasing. The district received 4,914 vouchers for the 2012/2013 farming season, which was 49.7 per cent less than the number of vouchers received in the previous year 2010/2011 which was 9,288 vouchers.

3.8.9 Limited Extension Services

Rainfall and temperature trends in the study villages are worse, whereby agro-pastoral communities need more assistance to increase their resilience. Extension services become very critical in the provision of information that could change livestock keeping and small-scale farming activities from subsistence to modern and commercial dimensions, thus improving agropastoral, increasing income, reducing poverty and improving households' food security. During the household survey, it was revealed that about 30.7 per cent of the respondents mentioned limited or sometimes the lack of extension services as a limiting factor in the adaption practices. The number of Extension Officers is very low compared to the number of villages and animals in the district. For instance, Kibirashi Ward had no Veterinary Officers, Livestock Officers, had one (1) Livestock Auxiliary Officer and three (3) Livestock Field Officers. Mkindi Ward had no any mentioned above, while Saunyi had no Veterinary Officers, Livestock Officers, Livestock Auxiliary Officers and had one (1) Livestock Field Officer.

4.0 Conclusion

It is evident that climate change and variability are real, and is affecting semiarid areas of Kiteto and Kilindi Districts through reduced livestock, crop production and thus causing food insecurity. The study concludes that the majority of agro-pastoral communities perceived climate change and variability through an observed decrease in rainfall amount, distribution and seasonal changes as well as increased temperature and droughts extremes which were also supported by archival data. Also, this study revealed that agropastoralists have implemented various pathways to increase their resilience to changing climate effects. However, because of physical and institutional limitations implementation of most adaptive measures to increase resilience are not effective forcing agro-pastoral communities to become more mobile in searching for water and pastures. Therefore, this study recommends to the government and other non-governmental organizations that, agropastoralists should be advised to keep more small ruminants (goats, sheep and chickens) as they are more adaptable than cattle. Also, maize and beans production in such marginal lands is not suitable and therefore agro-pastoralists should be advised to grow early maturing and drought-resistant crops such as sorghum and cassava. Additionally, agro-pastoralists in these fragile dryland environments need more capacity-building activities for increased awareness which makes them more resilient.

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